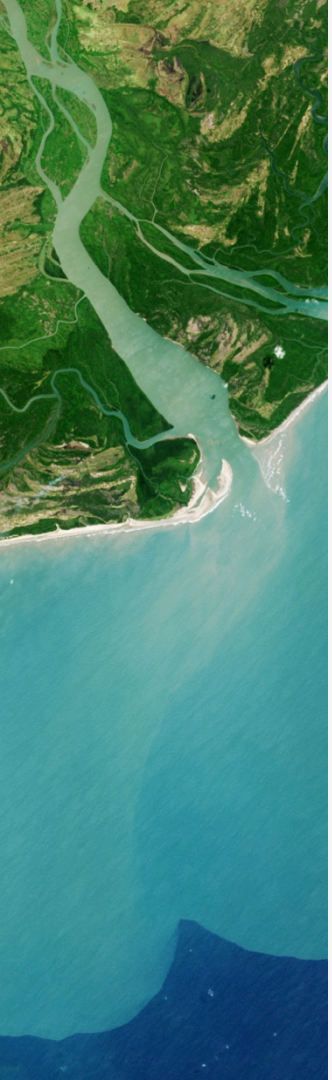


National Aeronautics and Space Administration

ARSET

Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

@NASAARSET

Introduction to Remote Sensing for Ocean and Coastal Applications

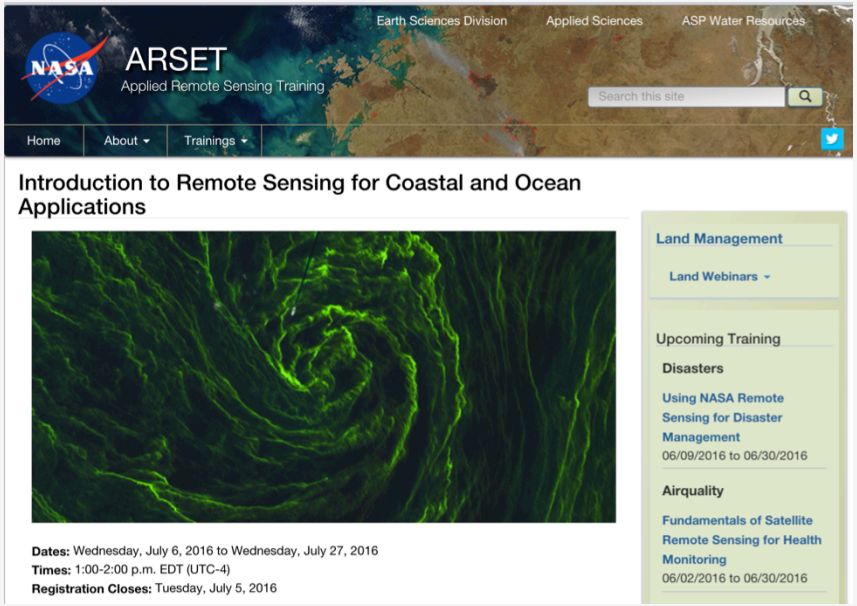
Week 4: Coral Reefs

Course Structure

- One lecture per week – every Wednesday July 6 – July 27
- 1:00 – 2:00 PM EDT (UTC-4)
  - Lectures
  - In-class demonstration
  - Homework exercises, due August 10th
- Webinar recordings, presentations, and homework assignments can be found after each session at:
  - http://arset.gsfc.nasa.gov/land/webinars/coastal-oceans-2016
- Q/A: Following each lecture and/or by email (sherry.l.palacios@nasa.gov)

Accessing Course Materials

http://arset.gsfc.nasa.gov/land/webinars/coastal-oceans-2016



Course Agenda:

Agenda.pdf

Session One: Overview of Satellite Remote Sensing of Aquatic Environments

July 6, 2016

An overview of themes in coastal and ocean applied science, how remote sensing is used for coastal and ocean applied science, fundamentals of remote sensing (spatial, temporal, spectral resolutions), and the advantages and limitations of remote sensing in aquatic environments. View the recording »

- Presentation Slides »

Session Two: Platforms and Sensors for Ocean Observations, Data Access, and Processing Tools

July 13, 2016

Satellites and sensors for coastal and ocean applications, satellite data processing levels, NASA satellite data access tools and data processing tools. View the recording »

- Presentation Slides »

Your Course Instructors

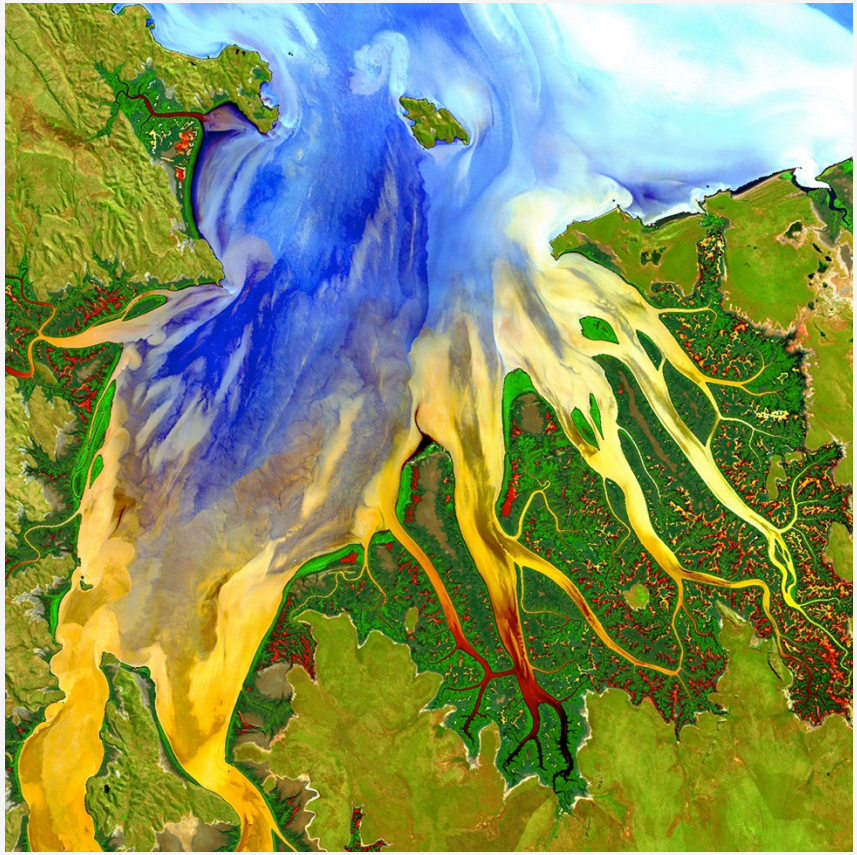
- Sherry Palacios: sherry.l.palacios@nasa.gov
- Amber McCullum: amberjean.mccullum@nasa.gov
- Cindy Schmidt: cynthia.l.schmidt@nasa.gov

- Guest Speakers:
  - Mitchell Roffer, Roffer's Ocean Fishing Forecast Service (Week 3)
  - Mark Eakin, NOAA Coral Reef Watch (Week 4)

- General ARSET Inquiries
  - Ana Prados: aprados@umbc.edu

Course Objectives

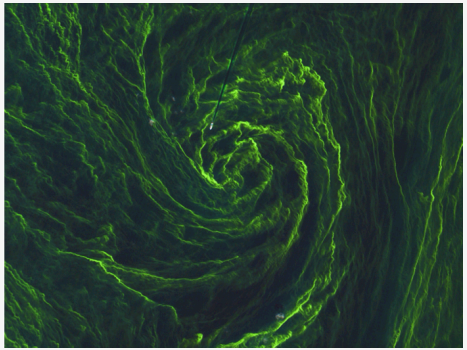
- Overview of NASA Earth Observation resources available for open ocean and coastal applications including:
  - A basic understanding of remote sensing of aquatic systems
  - How to access and visualize NASA Earth science data
  - How to use NASA Earth science data, tools, and products for ocean and coastal applied science issues
- Conduct live demonstrations of useful ocean and coastal applied science tools



Credit: NASA/USGS Landsat; Geoscience Australia

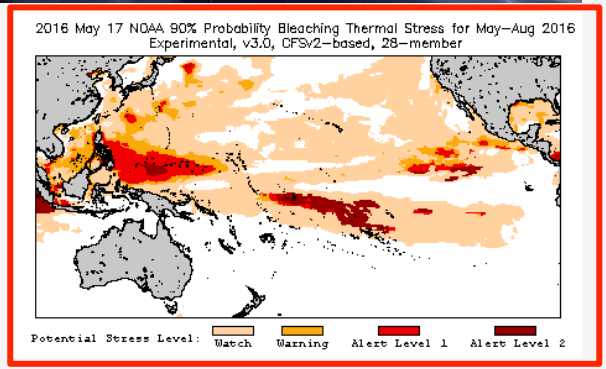
Course Outline

Week 1
Overview of
Satellite
Remote Sensing



Week 2
Platforms
and Sensors
for Ocean
Observations

Week 3
Animal
Movement



Week 4
Coral Reefs

Week 4 Agenda

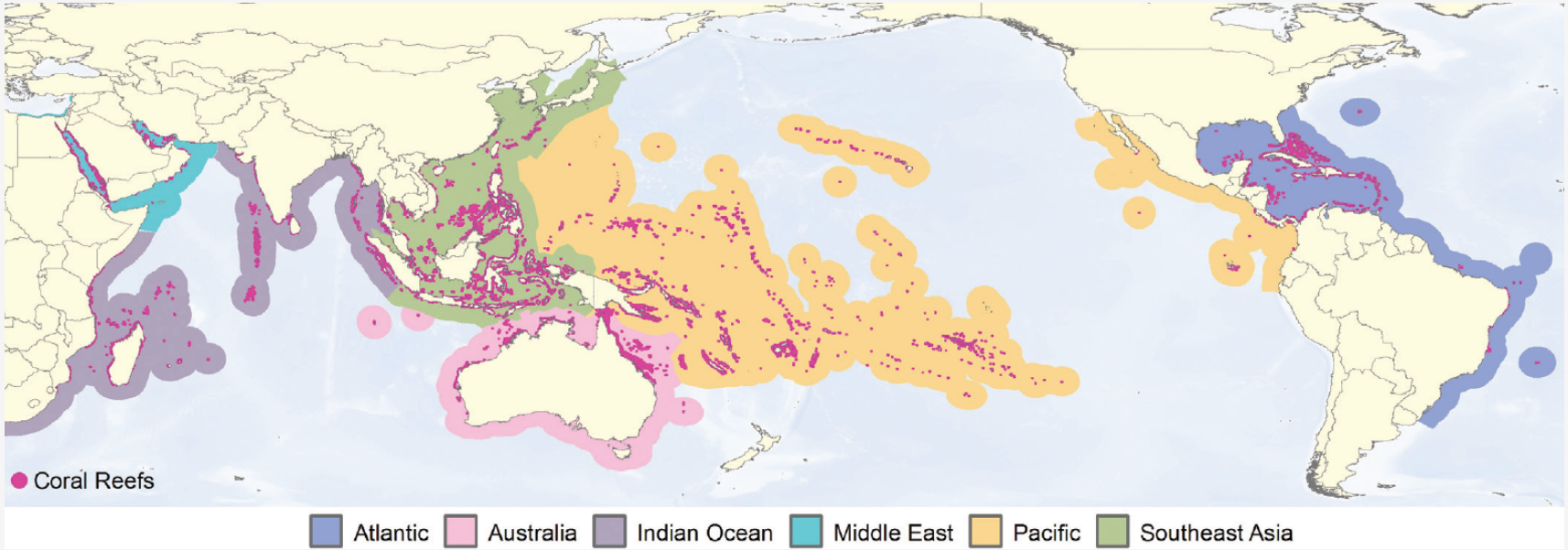
- Overview of coral biology
- Threats to coral reefs
  - Local
  - Global
- Remote sensing of coral reefs
- Examples of remote sensing tools for understanding coral reef systems
- Live Demo:
  - Dr. Mark Eakin: NOAA Coral Reef Watch

Credit: XL Catlin Seaview Survey, Osprey Reef, Great Barrier Reef

Overview of Coral Biology

Worldwide Distribution of Coral Reefs

Reefs at Risk Revisited (2011)



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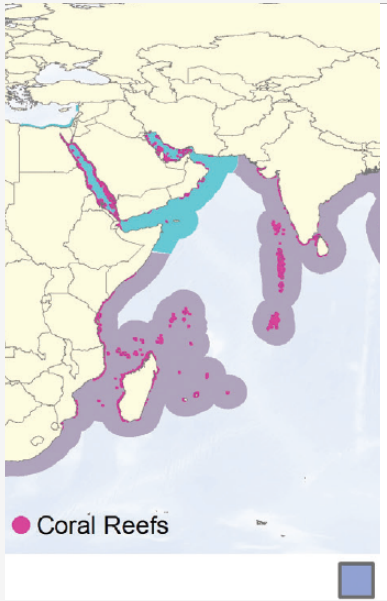
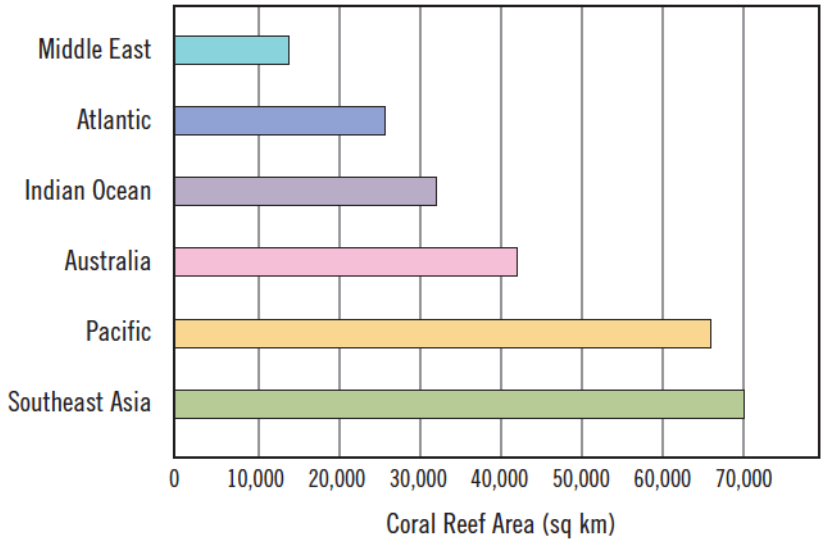
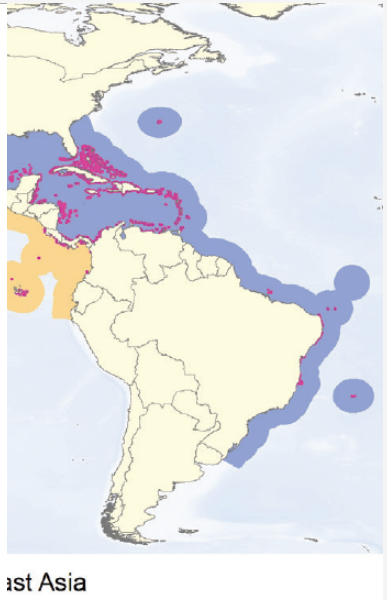






Credit: Reefs at Risk Revisited

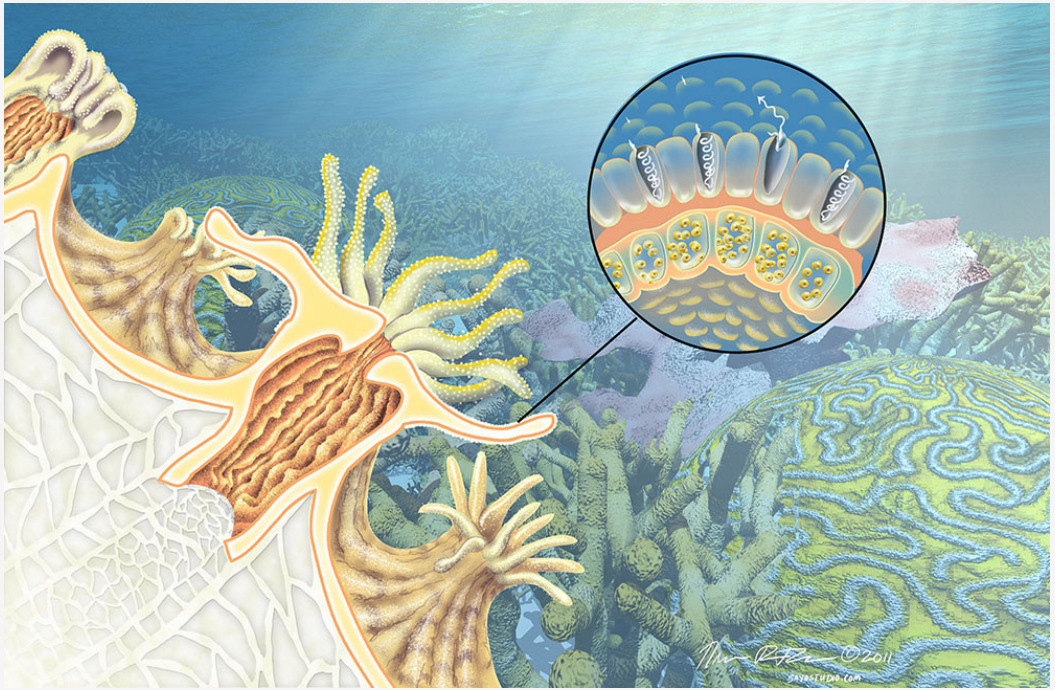
The Tropical Coral Reef and its Allies

- Scleractinian “stony” corals
- Mangroves
- Seagrasses
- Upland watersheds
- Open ocean

Credits: The Bahamas Trust, P. Selvaggio, B. Ross

Scleractinian Coral Biology

- Hundreds of thousands of tiny (1-3mm diameter) polyps make up a coral colony
- Secretes calcium carbonate skeleton that makes the coral “stony”
- Stings prey with tiny stinging cells called nematocysts
- Part of a mutually symbiotic relationship with dinoflagellate (commonly known as zooxanthellae)



Credit: NR Fuller, Sayo Studio

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Coral Reef Systems

- Ecosystem engineers
- Oases of biodiversity in the tropical ocean
- Nursery grounds for many animal species
- Hotspots of productivity

Credit: Reefs at Risk Revisited

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- Oases of biodiversity in the tropical ocean
- Nursery grounds for many animal species
- Hotspots of productivity

Biome	Productivity (kg C/ m2/yr)
Average Oceanic Areas	0.1
Temperate Grassland	1
Rainforest	1 - 2
Kelp Forest	2
Intensive Alfalfa Crop	1 - 2
Coral Reef	1.5 - 5

Threats to Coral Reefs

Threats to Coral Reefs

Reefs at Risk – Revisited (2011)

Local Threats

- Coastal Development
- Watershed-Based Pollution
- Marine-Based Pollution and Damage
- Overfishing and Destructive Fishing

Global Threats

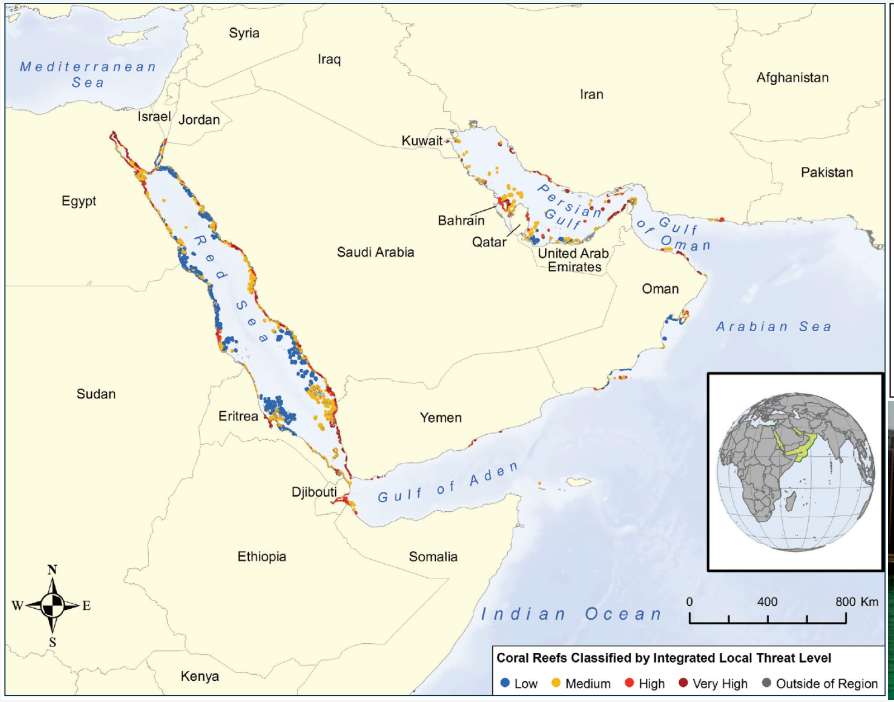
- Past Thermal Stress
- Future Thermal Stress
- Ocean Acidification

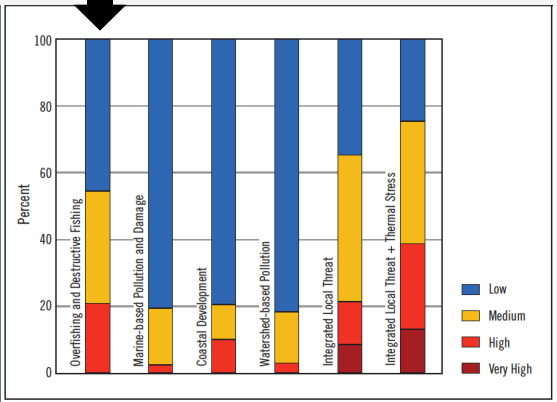
Credit: Reefs at Risk Revisited (http://www.wri.org/publication/reefs-risk-revisited), NASA JPL

Local Threats by Region

Middle East

Overfishing & Coastal Development



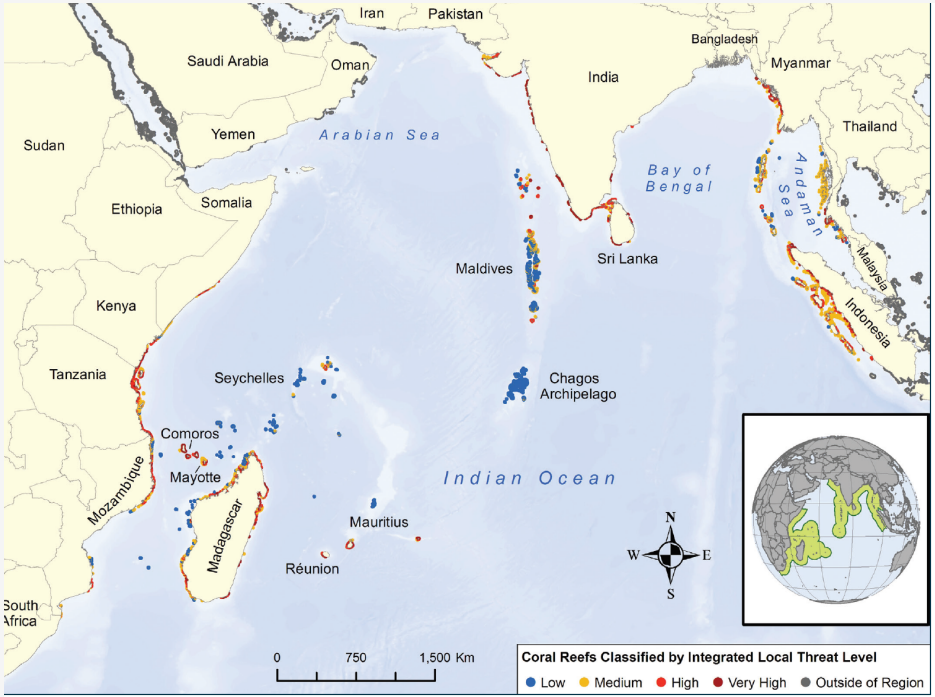


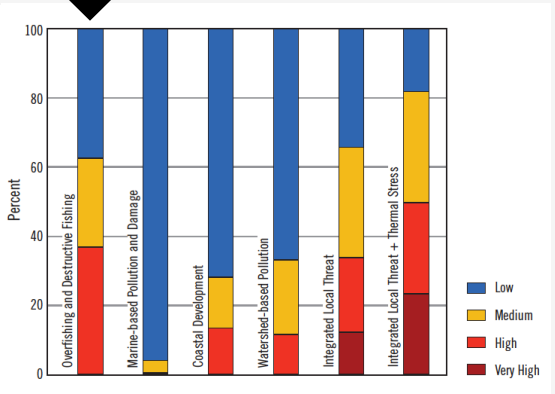
Credit: Reefs at Risk Revisited

Local Threats by Region

Indian Ocean

Overfishing



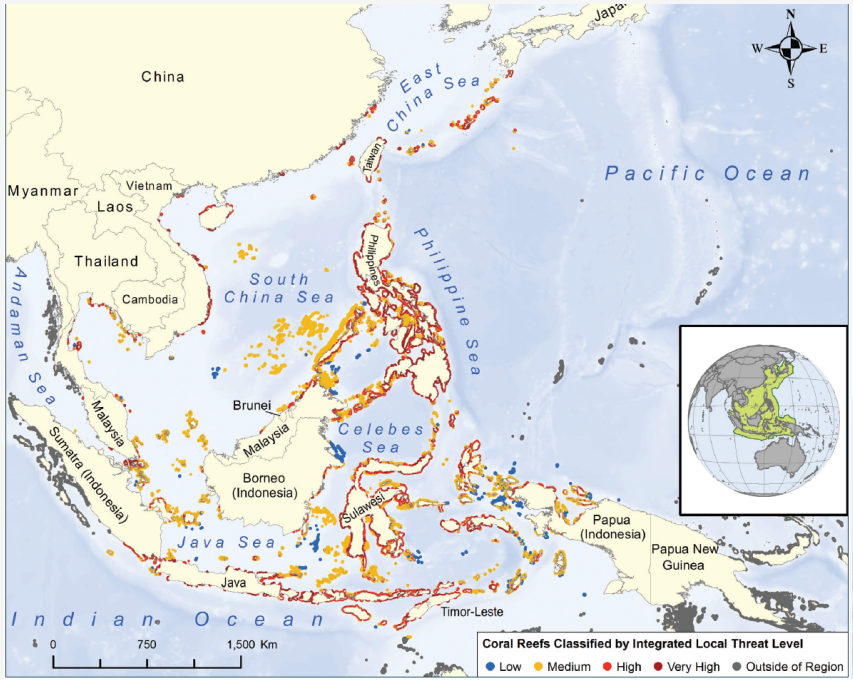


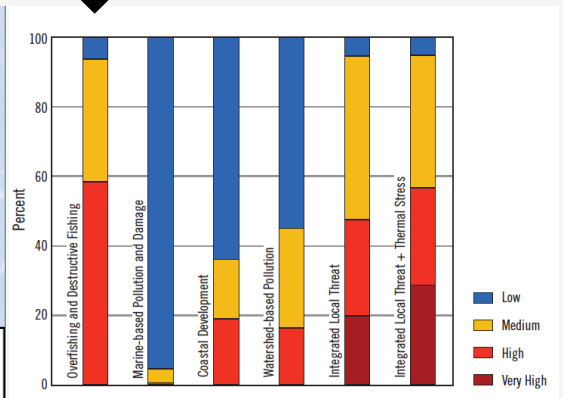
Credit: Reefs at Risk Revisited

Local Threats by Region

Southeast Asia

Overfishing



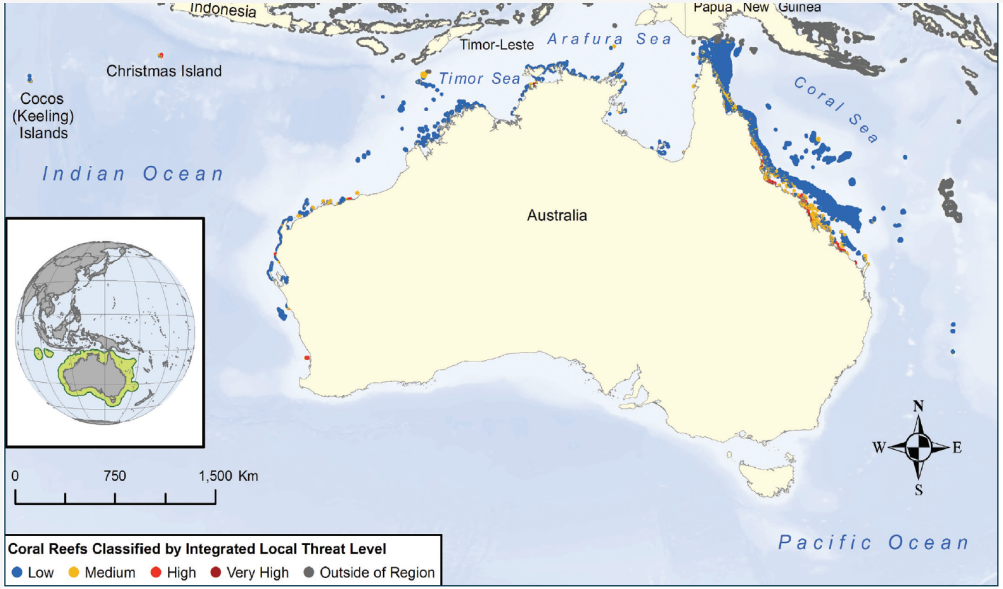


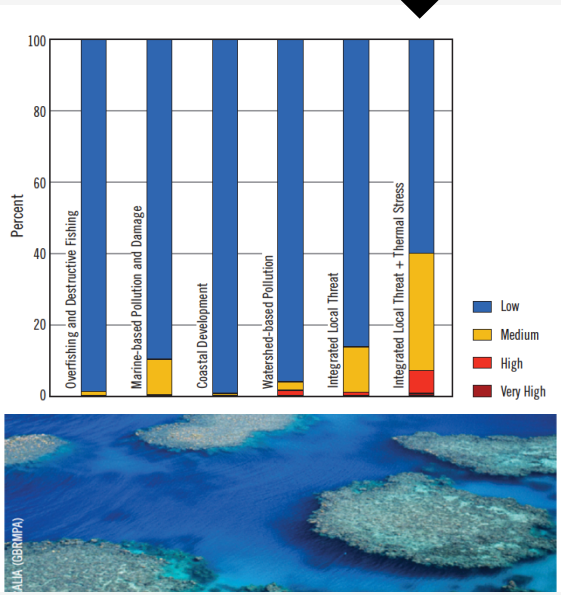
Credit: Reefs at Risk Revisited

Local Threats by Region

Australia

Integrated Global Threats: Climate Change

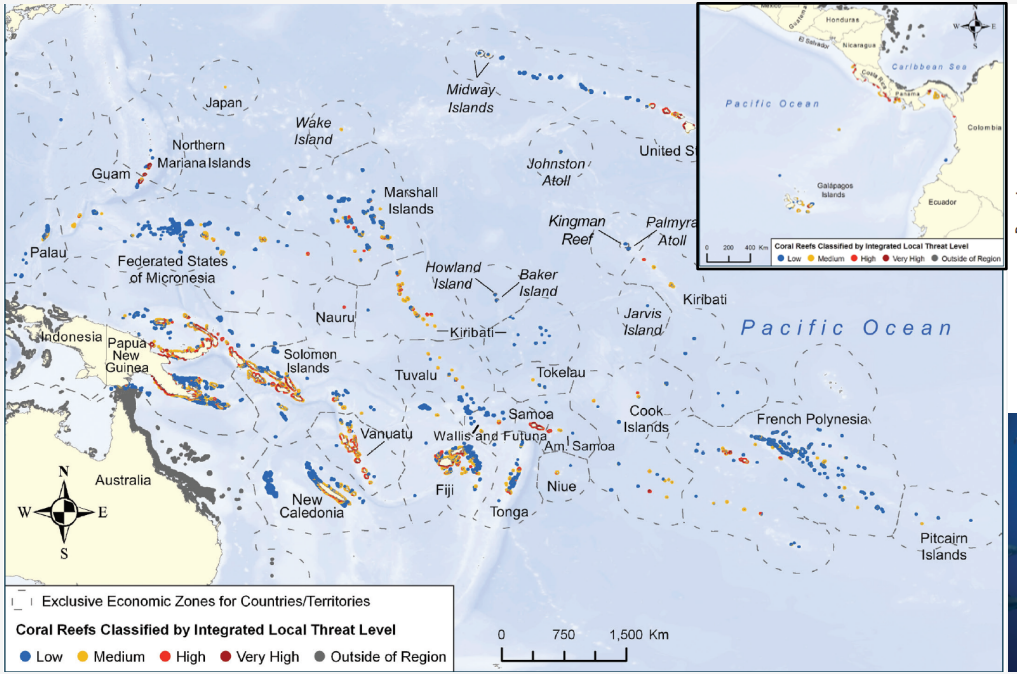




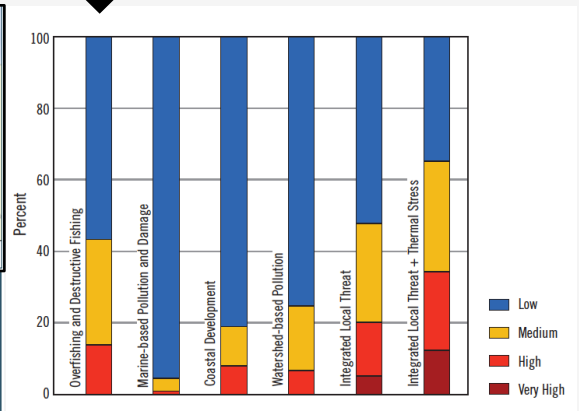
Credit: Reefs at Risk Revisited

Local Threats by Region

Pacific Ocean



Overfishing

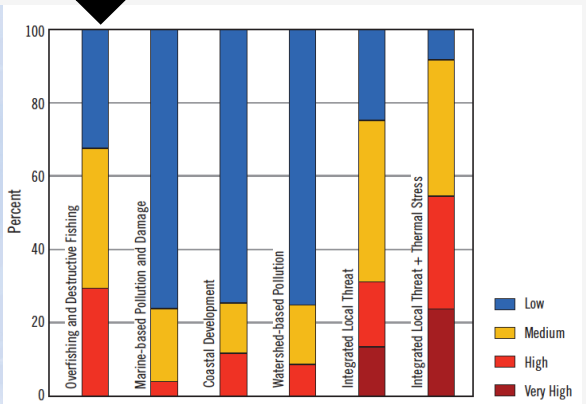


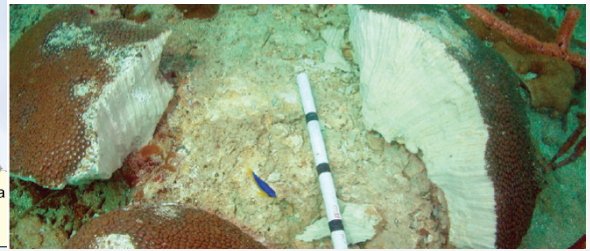
Credit: Reefs at Risk Revisited

Local Threats by Region

Caribbean Sea/Atlantic Ocean

Overfishing & Mechanical Destruction



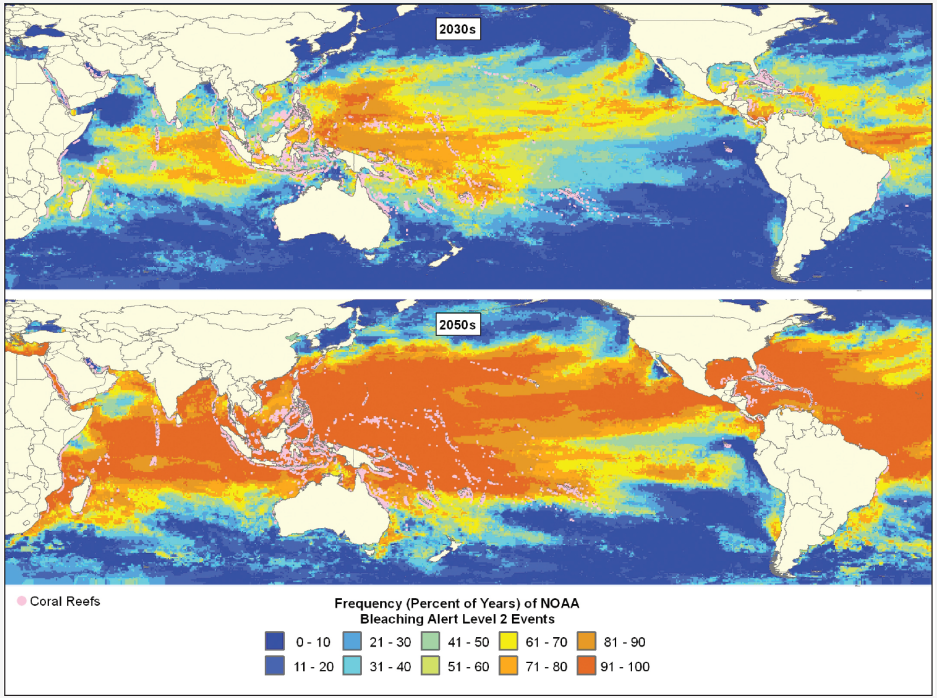


Credit: Reefs at Risk Revisited

Global Threats

Rising Ocean Temperature

- Ocean temperatures are rising with climate change
- Extended periods of above normal temperatures result in coral expelling zooxanthellae, pigment loss, or both. Also called coral bleaching
- 2014 – 2016 has been an unprecedented bleaching event
- Elevated temperature makes corals susceptible to disease



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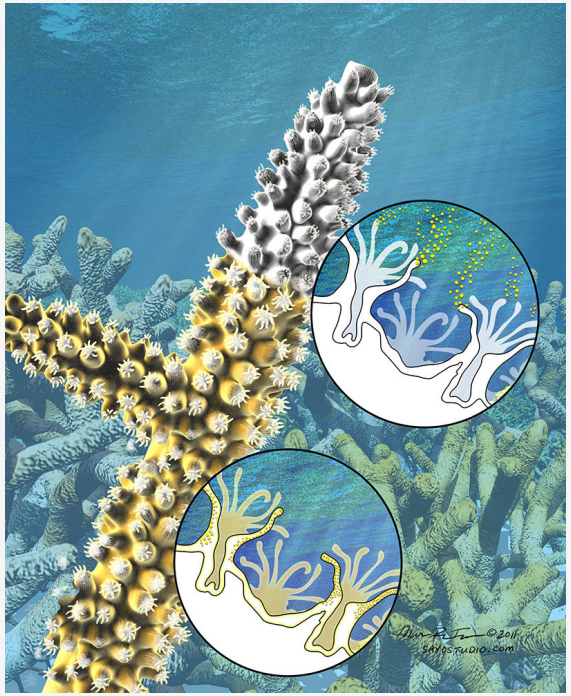

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Credit: XL Catlin Seaview Survey/Underwater Earth

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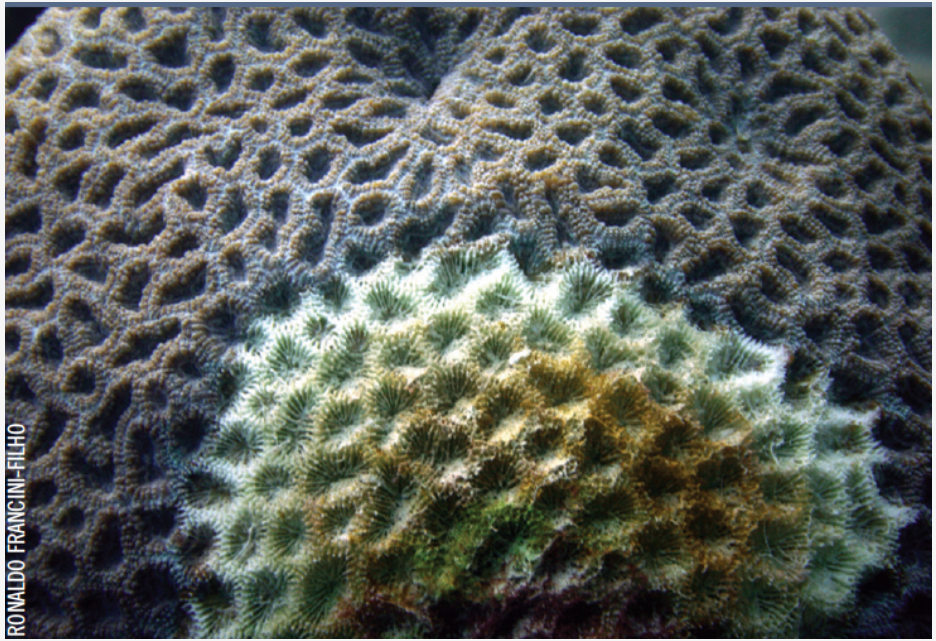
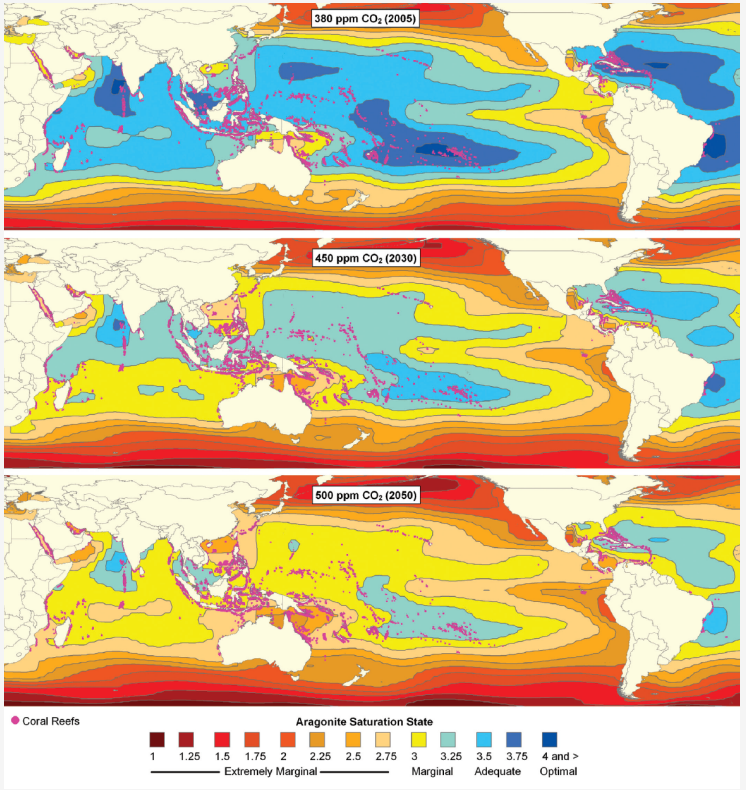


Credit: Reefs at Risk Revisited

Global Threats

Ocean Acidification

- Atmospheric CO_2 equilibrates with seawater resulting in rising ocean pCO_2
- CO_2 reacts with seawater causing a decrease in pH: it becomes more acidic
- Low pH water ‘dissolves’ calcium carbonate
- Coral skeletons are made of a particularly vulnerable crystal form of calcium carbonate known as aragonite
- Ocean acidification threatens the growth and sustainability of coral reef systems



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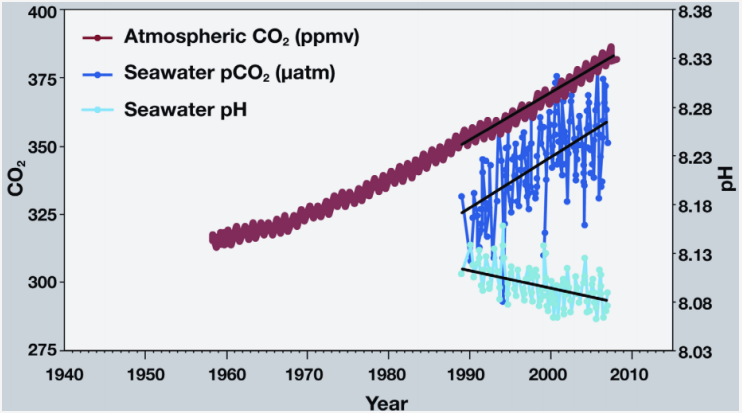


Credit: Modified from Feeley 2008

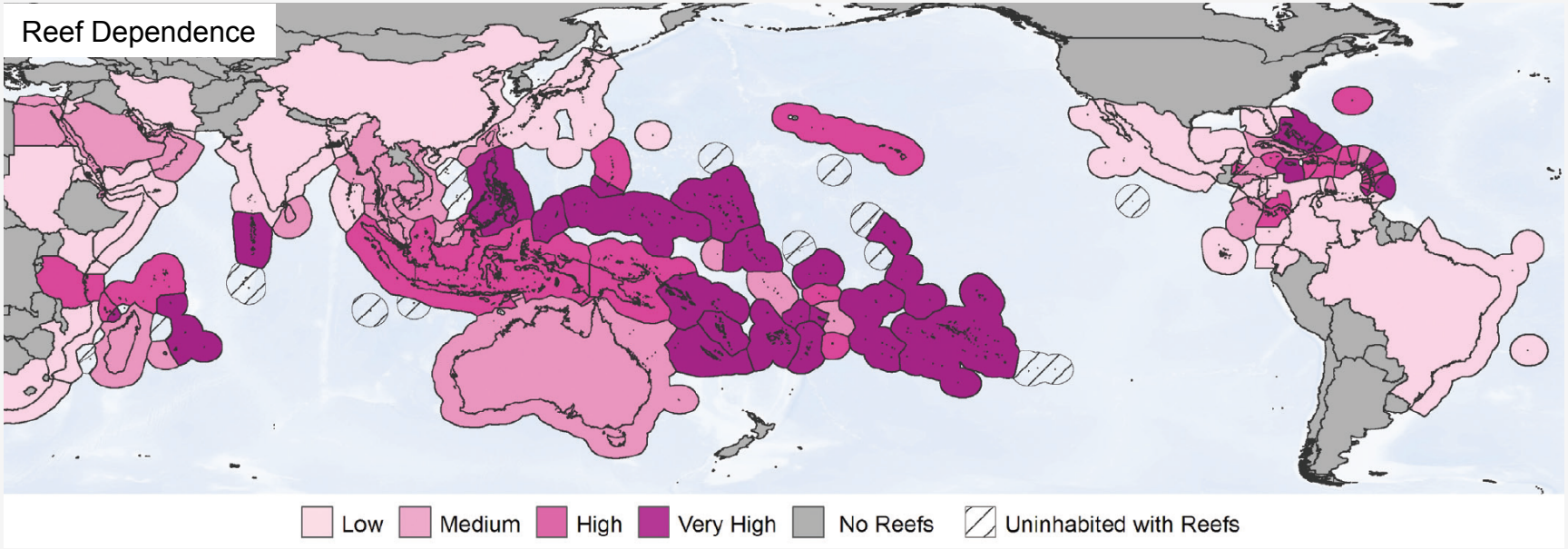
Characteristics of Degraded Coral Reefs

- Reduced habitat complexity
- Phase shifts from stony corals to fleshy macroalgae, soft corals, and sponges
- Reduced numbers of grazing fish
- Coral bleaching
- Physical destruction (e.g., from blast fishing)

Credit: XL Catlin Seaview Survey

Socio-Economic Consequences of Degraded Coral Reefs

Reef Dependence & Adaptive Capacity Govern Vulnerability



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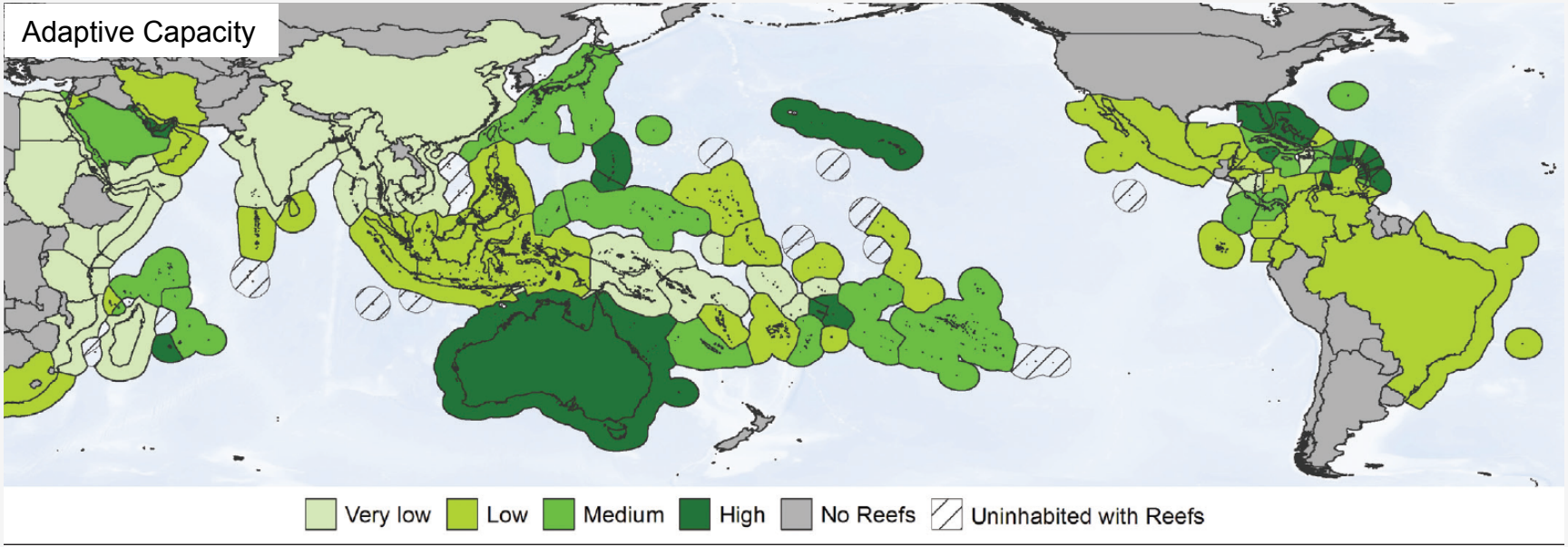

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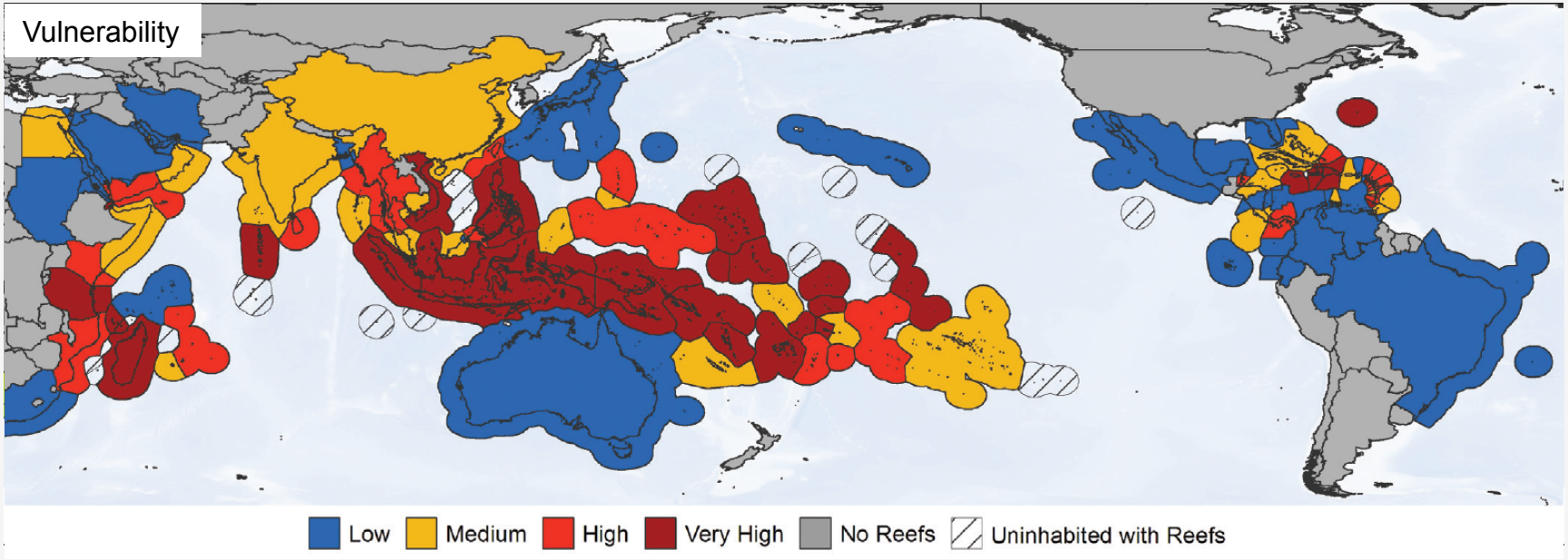

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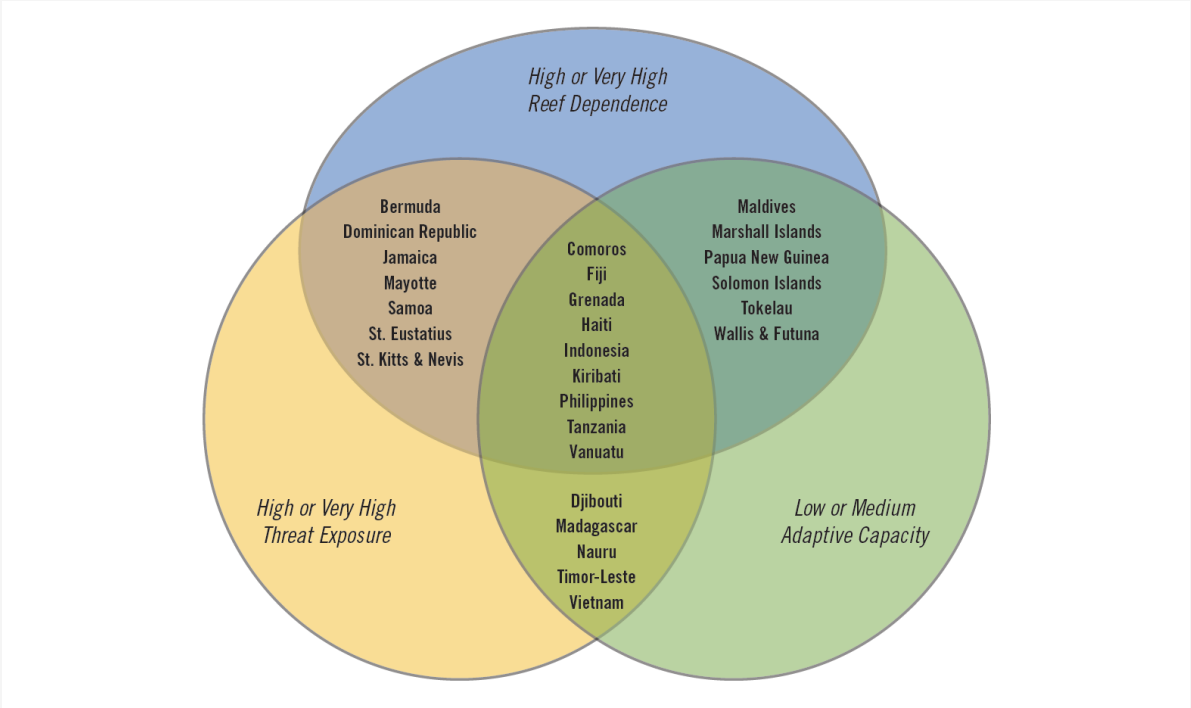
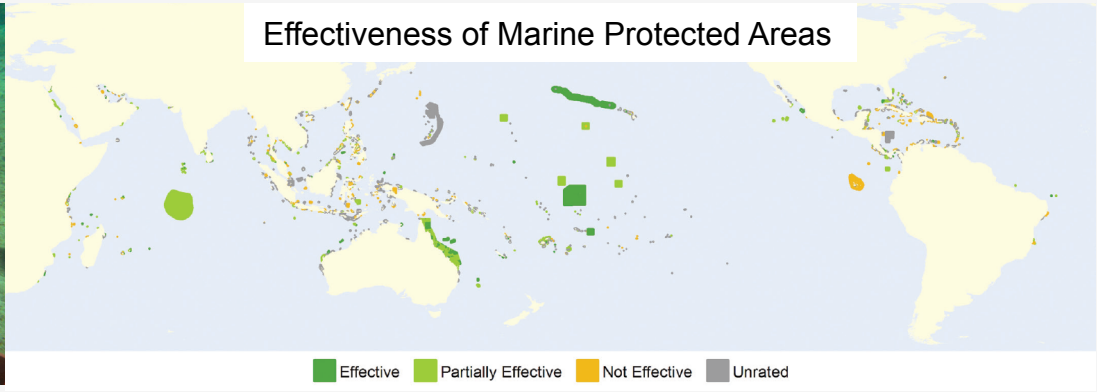


Credit: Reefs at Risk Revisited

Conservation

- Efforts are underway to ‘re-seed’ reefs after major bleaching events
- Marine protected areas (MPAs) and locally managed marine fisheries are being used to lessen the impact on top predators or grazers
- Remote sensing can be used to monitor reef condition



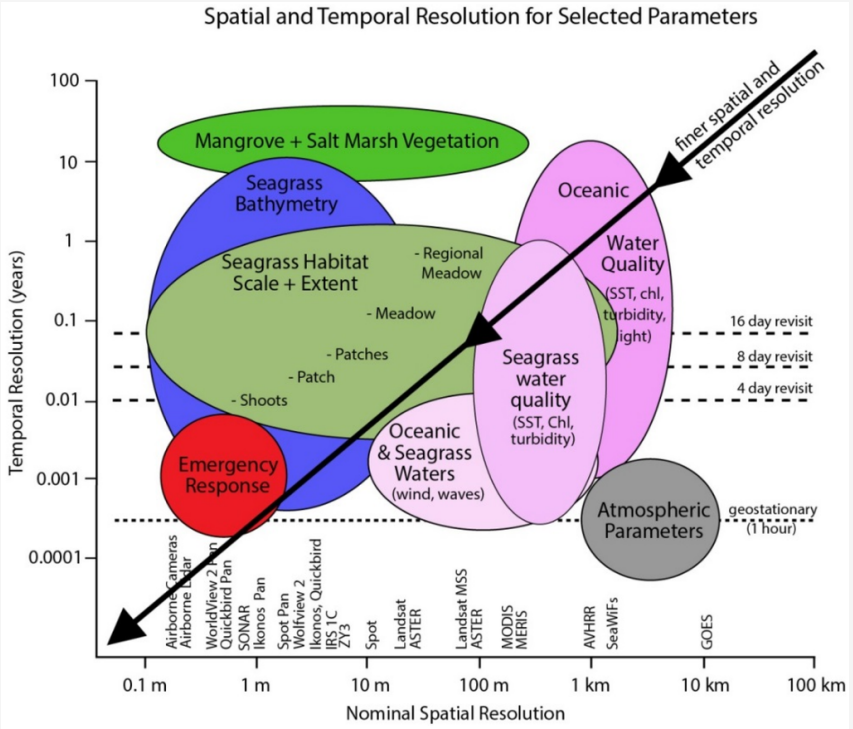
credit: Reefs at Risk Revisited

Remote Sensing of Coral Reefs

Remote Sensing for Coral Reef Monitoring

S. Phinn & C. Roelfsema, Editors

- Used to measure benthic type, reef structure, water quality, sea surface temperature
- Spatial, temporal, and spectral scale have large impact on the types of questions that can be asked
- Deriving coral productivity from imagery is in its early stages of development



Hedley et al. 2016

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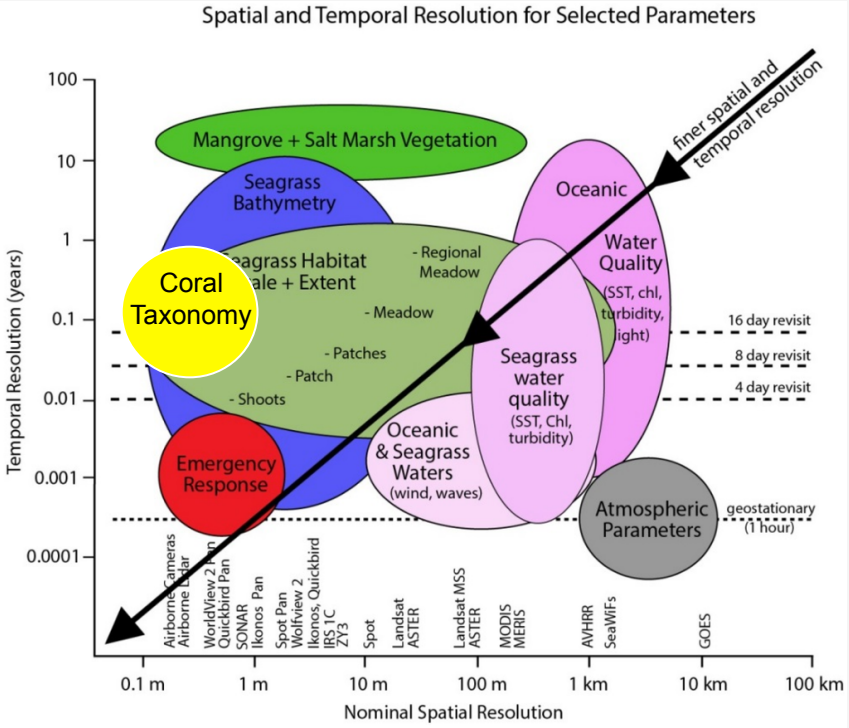

Hedley et al. 2016

Observing Environmental Factors with Remote Sensing

Hedley et al. 2016

Environmental Factor	Proxy/Measurement	Association	Sensor or Technology	Considerations
Photic Depth	light attenuation in water	high	moderate and high resolution satellites	Newer methods improve on limitations of standard ocean color algorithms in shallow coastal waters
Sedimentation	turbidity	medium	moderate and high resolution satellites	Sea floor reflectance in shallow waters limits the quantification of in-water constituents
Pollution	turbidity, algal blooms	low, low	moderate and high resolution satellites	Turbidity is proxy for pollution, algal blooms can help pin-point polluted areas
Exposure	wind energy and bathymetry	medium	satellite scatterometers for wind	Calculation of wave energy
Coastal Development	changes in land use	high	moderate and high spatial resolution multi-spectral satellites	Changes in land use can be proxy for coastal development
Overfishing	distance to reef-fishing from human settlement	low	airborne remote sensors, multi-spectral high resolution satellites	Settlements near reefs are more likely to exploit resources
Thermal Stress	SST	High	low spatial resolution radiometsrs	Direct measure of stress variable affecting corals
Ocean Acidification	SST, Sea Surface Salinity	Low	low spatial resolution radiometers	Can be used with other in situ and remote sensing data to derive seawater CO_2 concentrations

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Remote Sensing Technologies for Coral Reef Mapping

Hedley et al. 2016

Objective	Sensor Technology	Feasibility	Considerations
Reef Extent	High and moderate resolution satellites, airborne sensors	Routinely possible	Spatial heterogeneity at the locaiton determines the spatial resolution of the sensor to use
Rugosity	Boat and airborne active remote sensors	Routinely possible	Depth, turbidity and spatial heterogeneity at the location determine the acoustic method to use
Coral vs. Macroalgae	Hyperspectral airborne sensors	Demonstrated in **limited** cases only	Water column attenuation, presence of spectrally similar components and spatial heterogeneity at the location determine feasibility
Coral Mortality	Hyperspectral airborne sensors	Demonstrated in **limited** cases only	Water column attenuation, presence of spectrally similar components and spatial heterogeneity at the location determine feasibility
Coral Bleaching	Multispectral and hyperspectral airborne and satellite sensors	Demonstrated in **limited** cases only	Water column attenuation, presence of spectrally similar components and spatial heterogeneity at the location determine feasibility. Spectral confusion with sand to be avoided by comparison with imagery from earlier date
Bathymetry	Hyperspectral airborne and high resoluiton satellite sensors, acoustic and LIDAR	Routinely possible	Image processing effort is extensive

Remote Sensing Technologies for Coral Reef Mapping

Hedley et al. 2016

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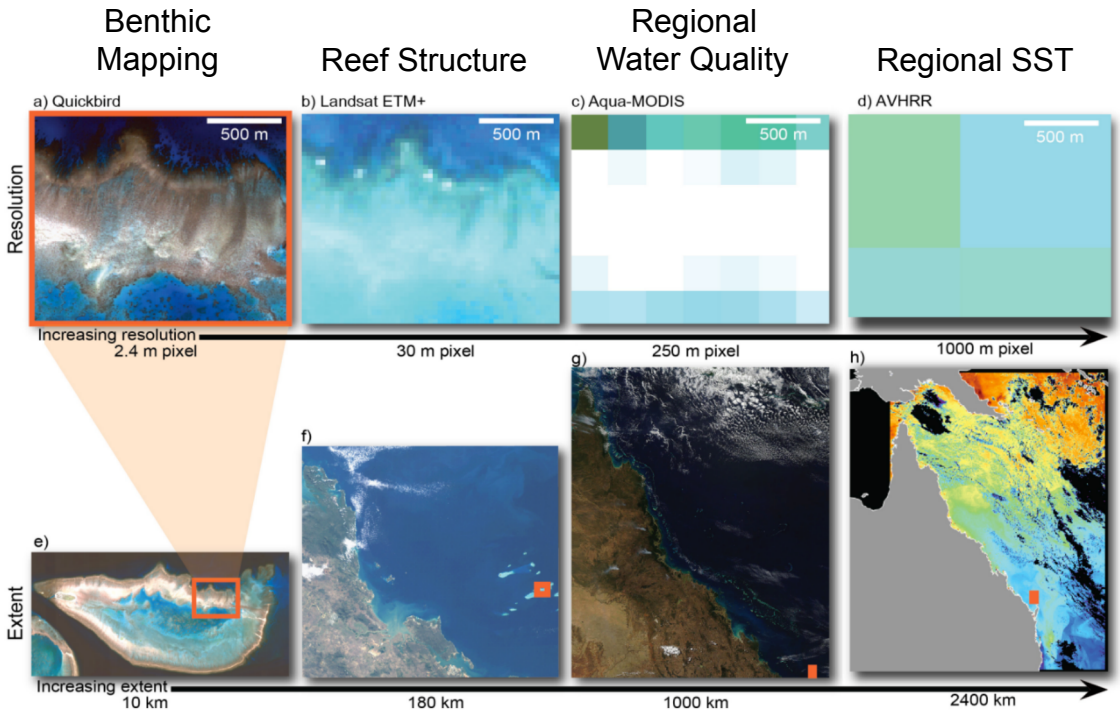
Reef Extent	High and moderate resolution satellites, airborne sensors	Routinely possible	Spatial heterogeneity at the locaiton determines the spatial resolution of the sensor to use
Rugosity	Boat and airborne active remote sensors	Routinely possible	Depth, turbidity and spatial heterogeneity at the location determine the acoustic method to use
Coral vs. Macroalgae	Hyperspectral airborne sensors	Demonstrated in **limited** cases only	Water column attenuation, presence of spectrally similar components and spatial heterogeneity at the location determine feasibility
Coral Mortality	Hyperspectral airborne sensors	Demonstrated in **limited** cases only	Water column attenuation, presence of spectrally similar components and spatial heterogeneity at the location determine feasibility
Coral Bleaching	Multispectral and hyperspectral airborne and satellite sensors	Demonstrated in **limited** cases only	Water column attenuation, presence of spectrally similar components and spatial heterogeneity at the location determine feasibility. Spectral confusion with sand to be avoided by comparison with imagery from earlier date
Bathymetry	Hyperspectral airborne and high resoluiton satellite sensors, acoustic and LIDAR	Routinely possible	Image processing effort is extensive

Spatial Scale Needed for Imagery Varies by Question

Example: Heron Island, Australia

Example Question:

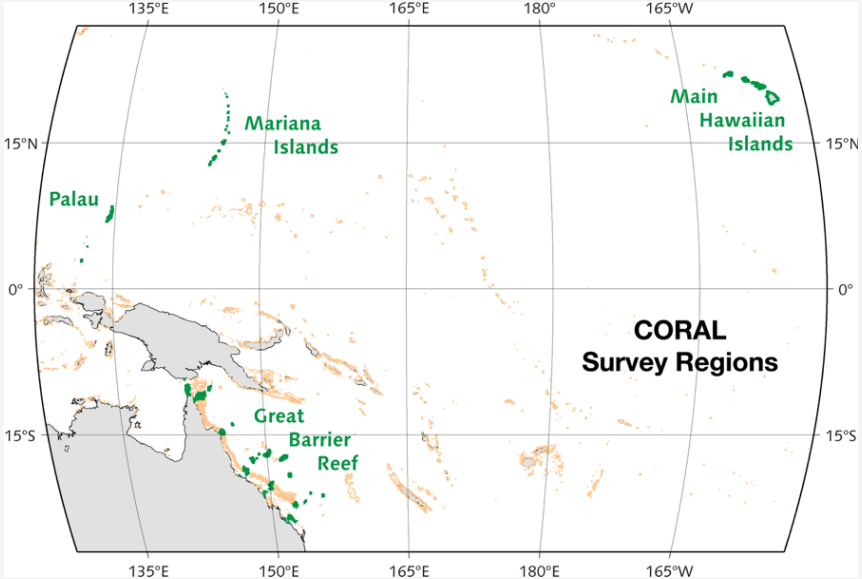


Hedley et al. 2016

NASA CORAL Earth Venture

https://coral.jpl.nasa.gov/; http://coral.bios.edu/

- COral Reef Airborne Laboratory (CORAL)
- Question: What is the relationship between coral reef condition and biogeophysical forcing parameters?
  - Measure condition of corals: proportion of coral, algae, and sand, calcification, and primary productivity
  - Establish empirical models (some using remote sensing inputs) to assess coral condition
- Sensor: Portable Remote Imaging SpectroMeter (PRISM)



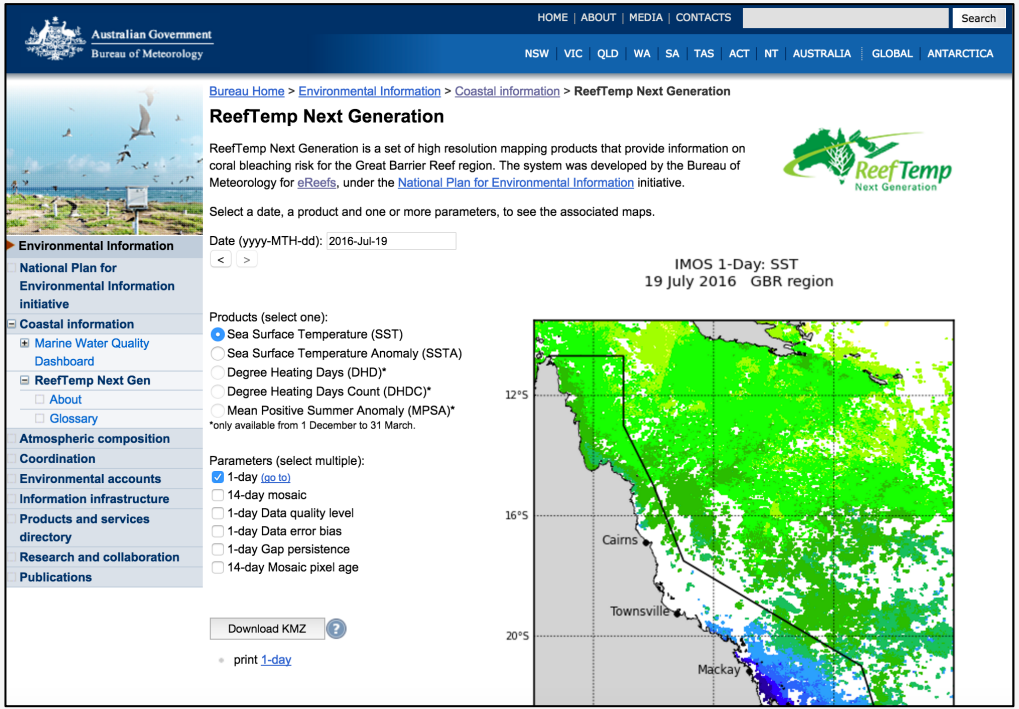
credit: E. Hochberg

Examples of Remote Sensing Tools for Understanding Coral Reef Systems

Australia's eReefs

ReefTemp

- ReefTemp is a web interface to view sea surface temperature data for the Great Barrier Reef
- It is a data portal that provides near real-time access to water temperature data
- It is freely available

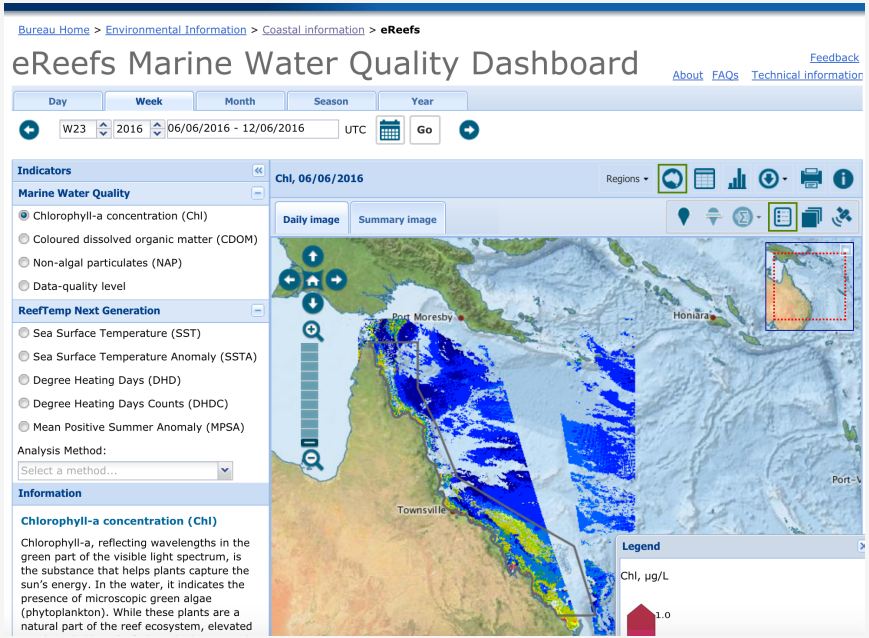


http://www.bom.gov.au/environment/activities/reeftemp/reeftemp.shtml

Australia's eReefs

eReefs Marine Water Quality Dashboard

- The transparency of the water column has a big impact on coral health
- The dashboard is a data portal that provides near real-time access to water quality data for different reef regions of Australia
- The tool permits viewing, statistics, and the download of data
- It is freely available



http://www.bom.gov.au/marinewaterquality/

Australia's eReefs

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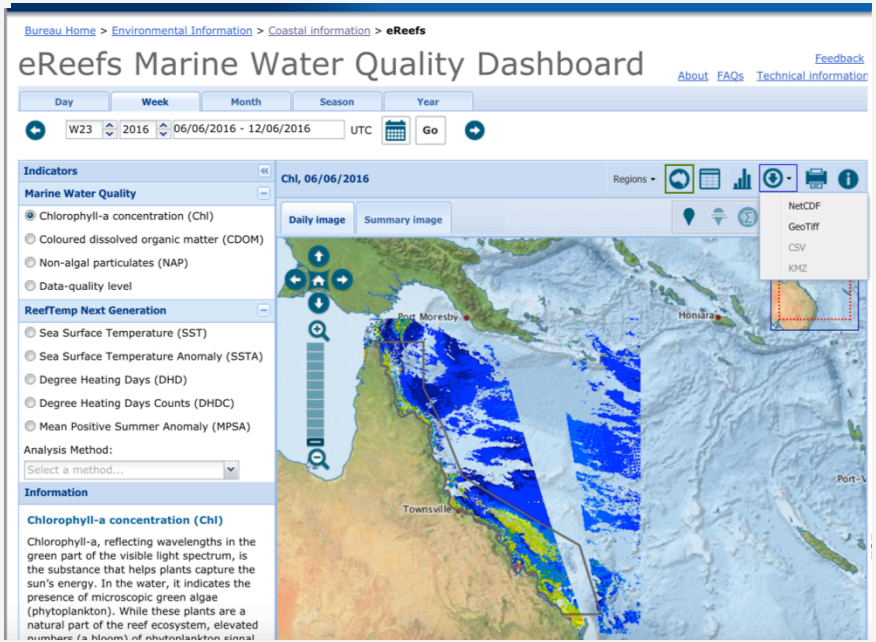
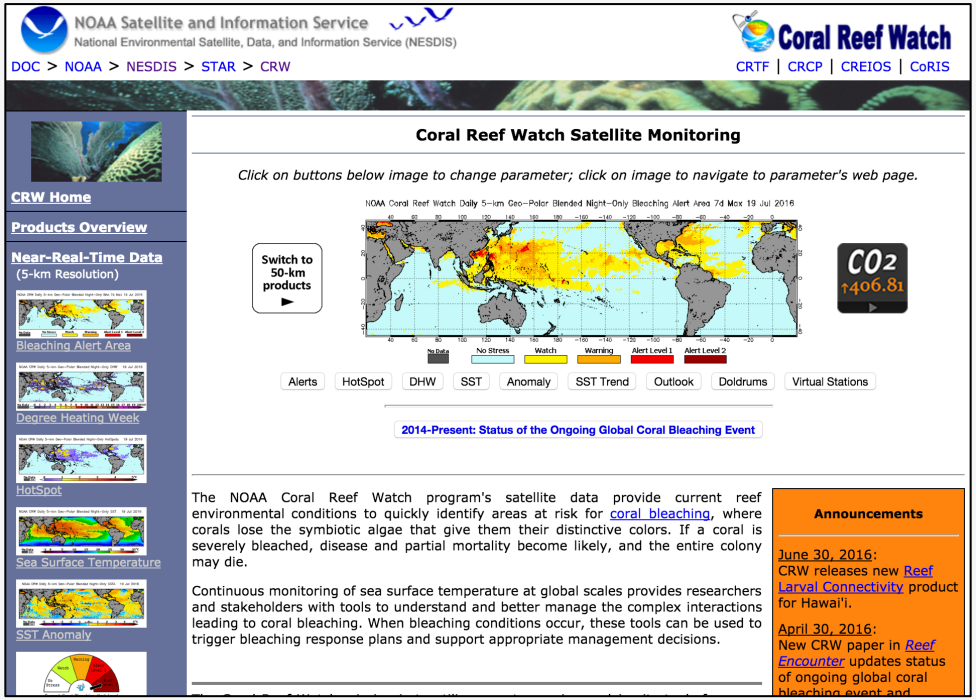


http://www.bom.gov.au/marinewaterquality/

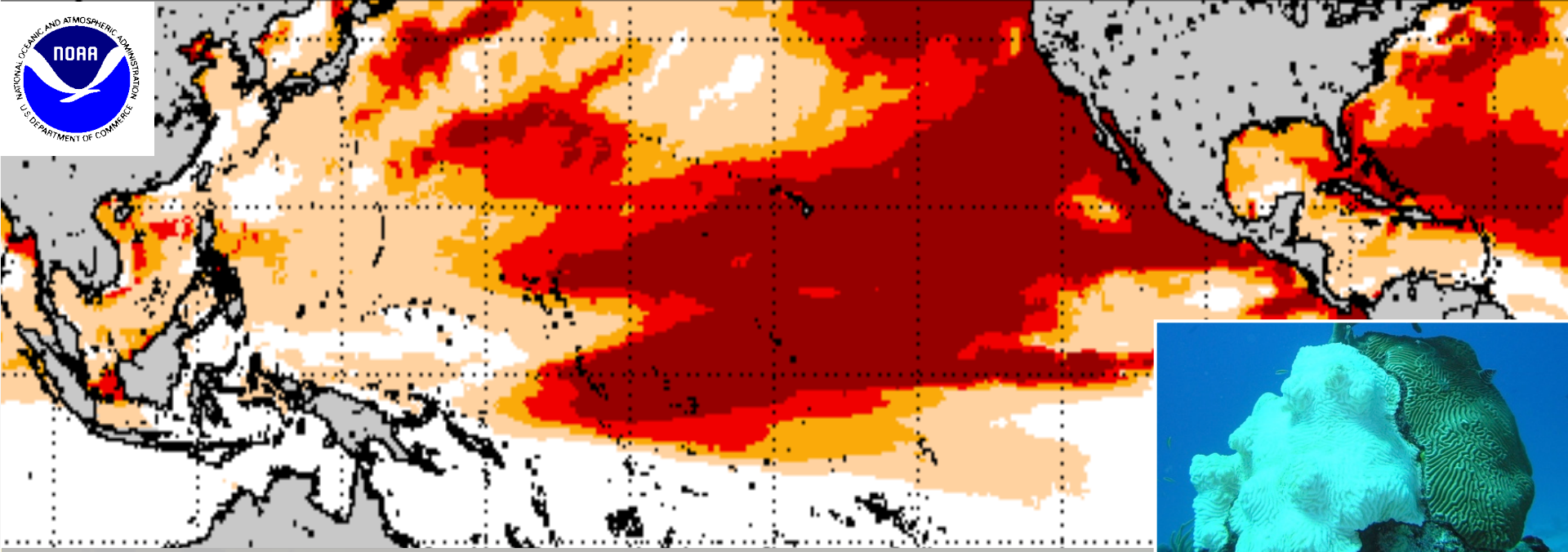
Special Guest: Dr. Mark Eakin

NOAA Coral Reef Watch http://coralreefwatch.noaa.gov/satellite/index.php



http://coralreefwatch.noaa.gov/satellite/education/tutorial/crw29_exercises.php

Live Demo: NOAA Coral Reef Watch



NOAA Coral Reef Watch:
Coral Bleaching Products and the Biggest Bleaching Event in History

Dr. C. Mark Eakin
NOAA Coral Reef Watch
http://coralreefwatch.noaa.gov

2015 Coral Bleaching: American Samoa

December 2014

XL CATLIN SEAVIEW™ SURVEY

http://coralreefwatch.noaa.gov

2015 Coral Bleaching: American Samoa

February 2015

XL CATLIN SEAVIEW™ SURVEY

http://coralreefwatch.noaa.gov

2015 Coral Bleaching: American Samoa

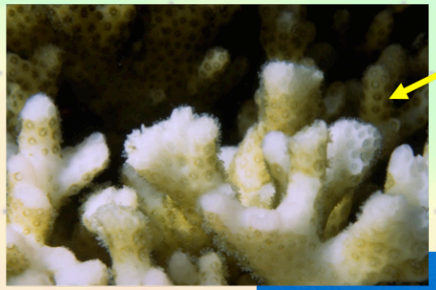
August 2015

XL CATLIN SEAVIEW™ SURVEY

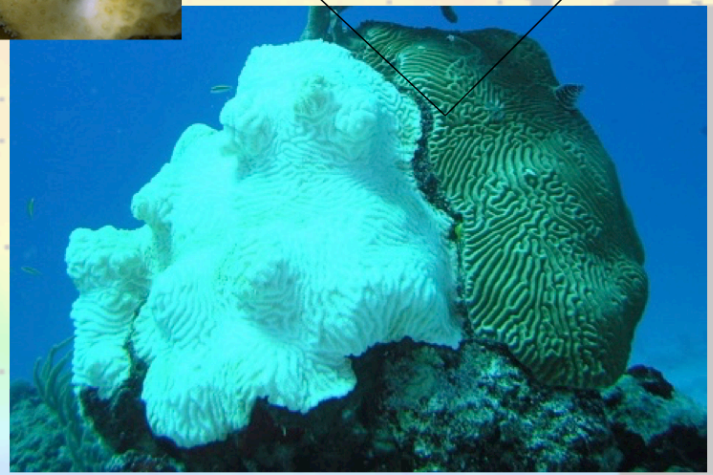
http://coralreefwatch.noaa.gov

What is Coral Bleaching?

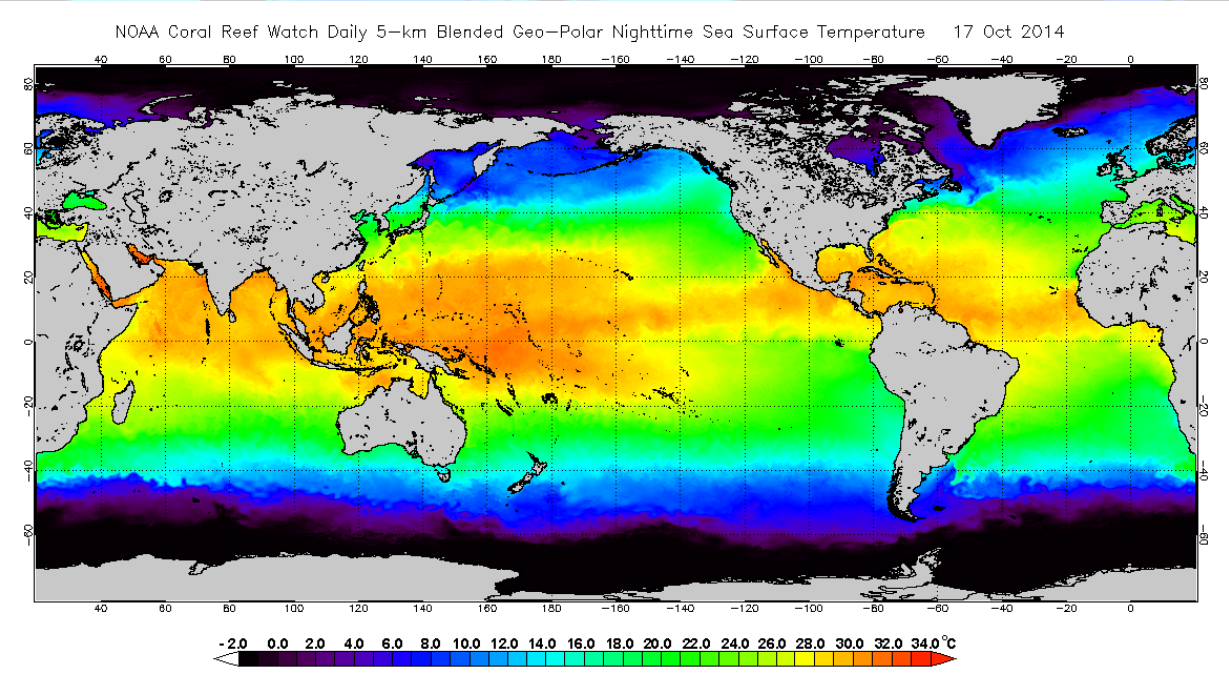
- Most of corals' food comes from photosynthesis
- Corals can "bleach" due to stress
- Corals exposed to high temperatures and/or high light become stressed
- Corals eject their algae; coral appears "bleached"
  - If stress is mild or brief, corals recover, otherwise they die



Symbiotic algae



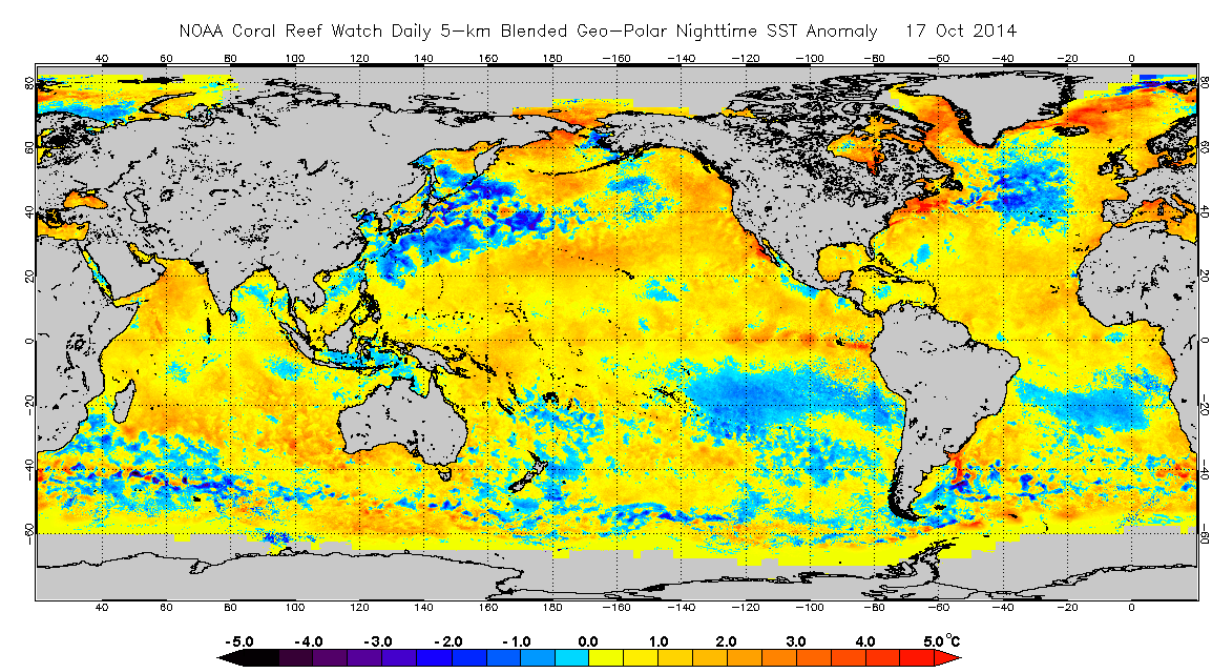
Coral Reef Watch
5-km Satellite-Based Products



Sea Surface Temperature

http://coralreefwatch.noaa.gov

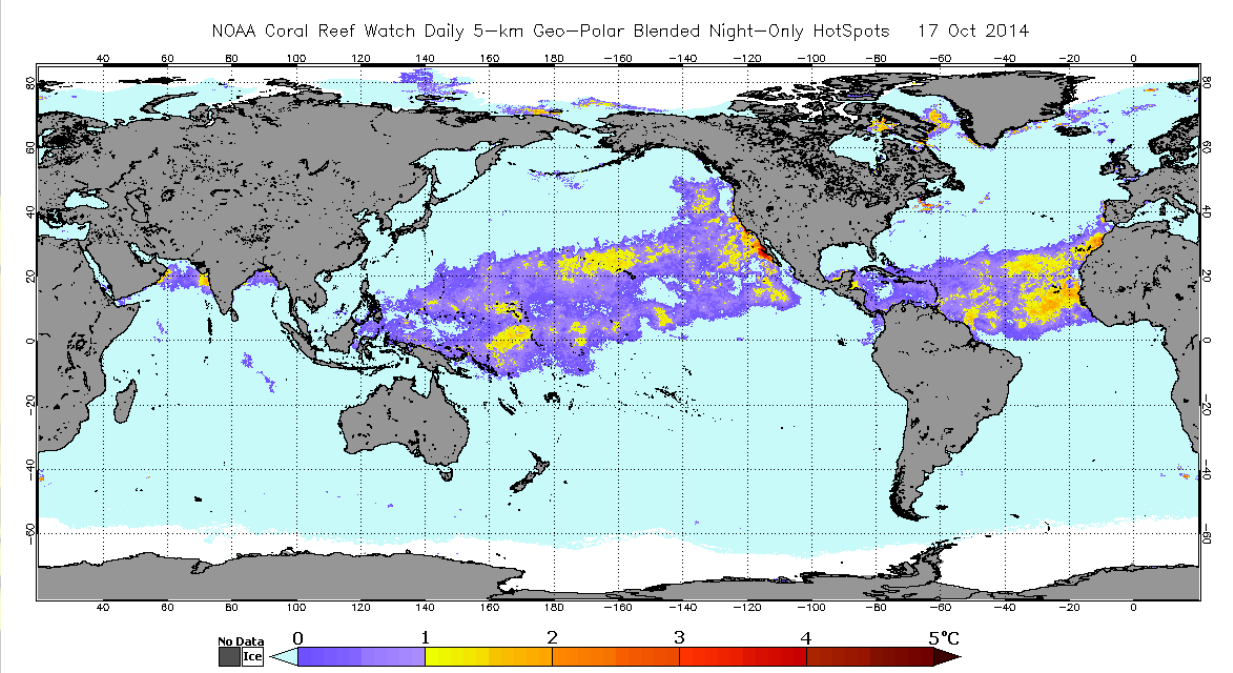
Coral Reef Watch
5-km Satellite-Based Products



SST Anomaly

http://coralreefwatch.noaa.gov

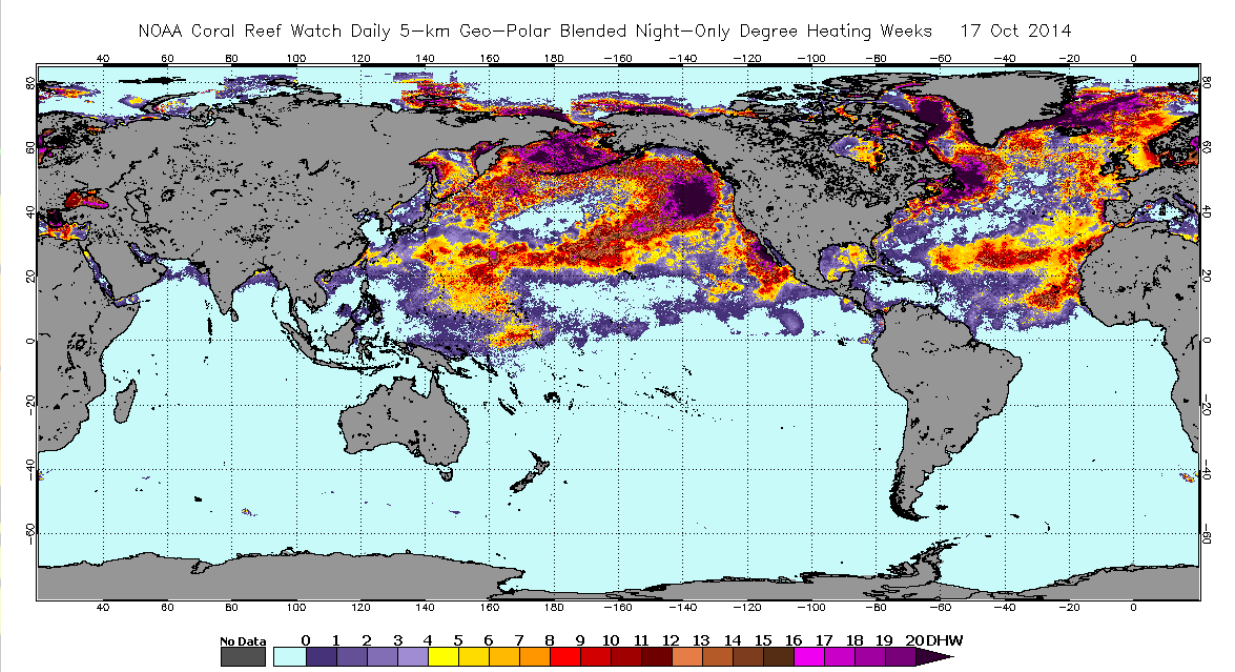
Coral Reef Watch
5-km Satellite-Based Products



HotSpot

http://coralreefwatch.noaa.gov

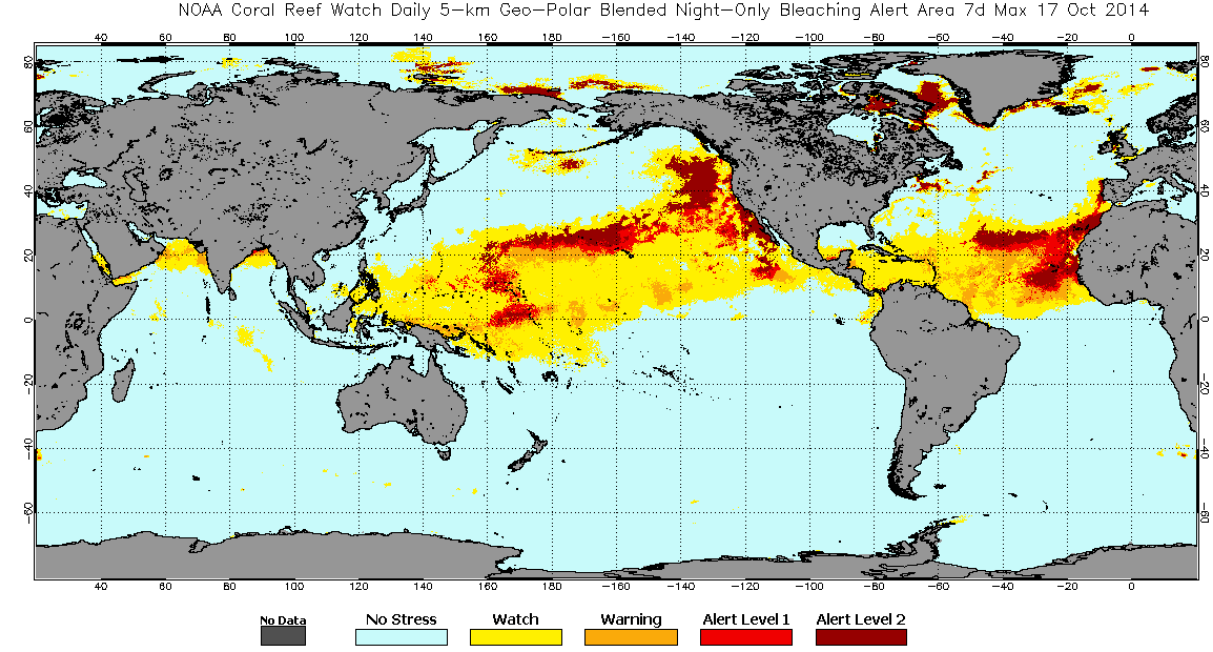
Coral Reef Watch
5-km Satellite-Based Products



Degree Heating Week

http://coralreefwatch.noaa.gov

Coral Reef Watch
5-km Satellite-Based Products



Bleaching Alert Area

http://coralreefwatch.noaa.gov

Coral Reef Watch: Product Comparison

5 km Geostationary-Polar Blend

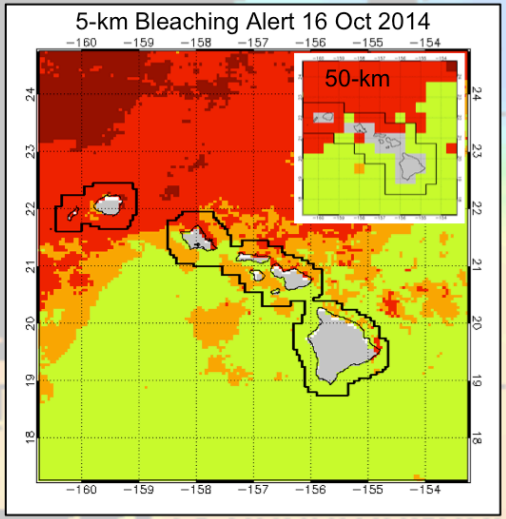
- **Climatology:** 22 year, 4 km (Pathfinder AVHRR)
- **Data:**
  - 5 km Operational Blended, night only
  - Polar-orbiters (2) + Geostationary (4)
  - Up to 50 scenes/day

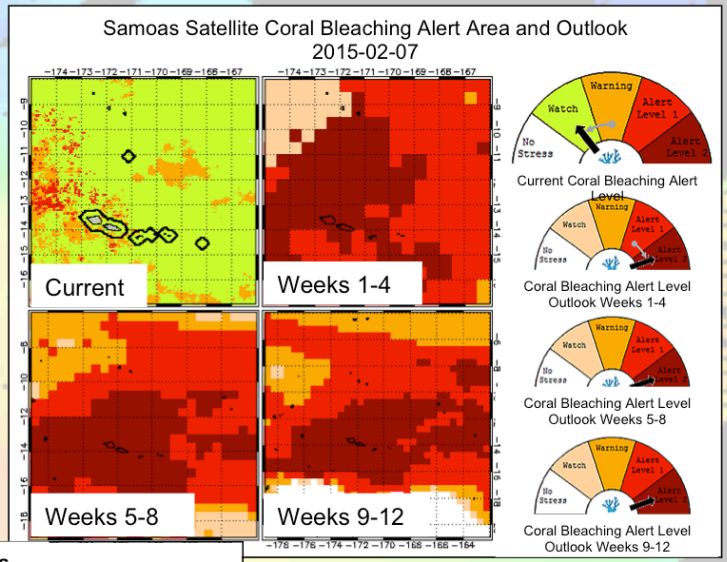
50 km Polar-only (Operational)

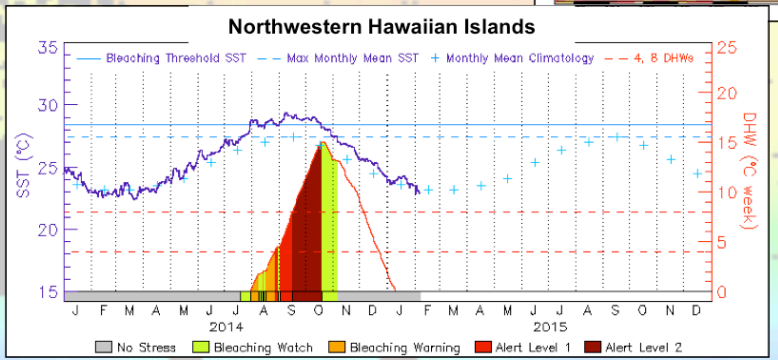
- **Climatology:** 7 year, 50 km (AVHRR)
- **Data:**
  - 50 km Operational, night only
  - Polar-orbiter (1)
  - Max 1 scene/day

http://coralreefwatch.noaa.gov

2014-5: New Coral Reef Watch
5-km Product Suite for Coral Bleaching

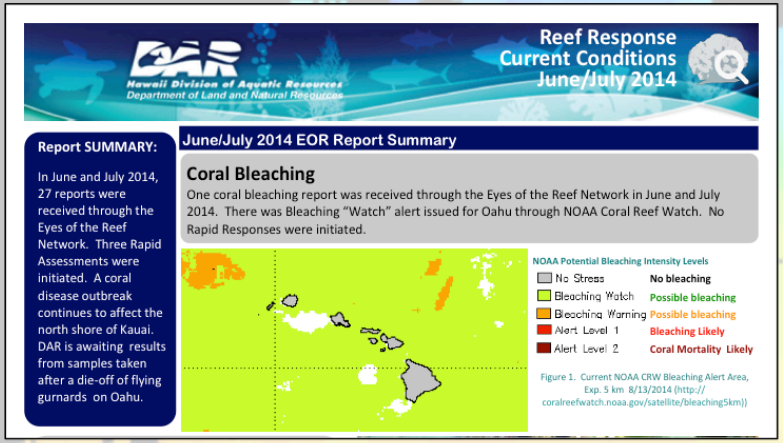






http://coralreefwatch.noaa.gov

Local Use of 5-km products



Hawaii Division of Aquatic Resources
Department of Land and Natural Resources

Reef Response
Current Conditions
June/July 2014

Report SUMMARY:

In June and July 2014, 27 reports were received through the Eyes of the Reef Network. Three Rapid Assessments were initiated. A coral disease outbreak continues to affect the north shore of Kauai. DAR is awaiting results from samples taken after a die-off of flying gurnards on Oahu.

June/July 2014 EOR Report Summary

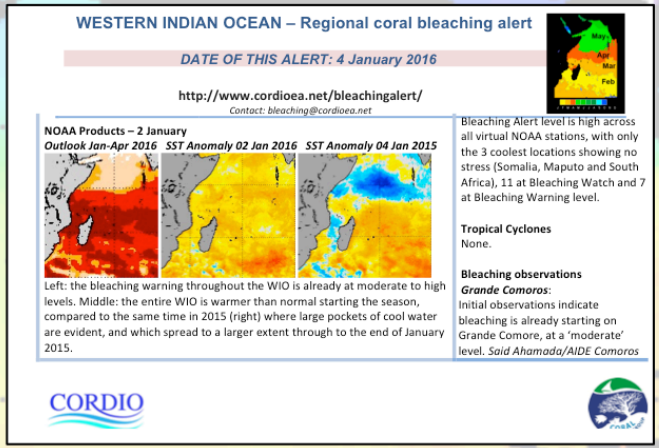
Coral Bleaching

One coral bleaching report was received through the Eyes of the Reef Network in June and July 2014. There was Bleaching "Watch" alert issued for Oahu through NOAA Coral Reef Watch. No Rapid Responses were initiated.

NOAA Potential Bleaching Intensity Levels

No Stress	No bleaching
Bleaching Watch	Possible bleaching
Bleaching Warning	Possible bleaching
Alert Level 1	Bleaching Likely
Alert Level 2	Coral Mortality Likely

Figure 1. Current NOAA CRW Bleaching Alert Area, Exp. 5 km 8/13/2014 (http://coralreefwatch.noaa.gov/satellite/bleaching5km))



WESTERN INDIAN OCEAN – Regional coral bleaching alert

DATE OF THIS ALERT: 4 January 2016

http://www.cordioea.net/bleachingalert/

Contact: bleaching@cordioea.net

NOAA Products – 2 January

Outlook Jan-Apr 2016 *SST Anomaly 02 Jan 2016* *SST Anomaly 04 Jan 2015*

Left: the bleaching warning throughout the WIO is already at moderate to high levels. Middle: the entire WIO is warmer than normal starting the season, compared to the same time in 2015 (right) where large pockets of cool water are evident, and which spread to a larger extent through to the end of January 2015.

Bleaching Alert level is high across all virtual NOAA stations, with only the 3 coolest locations showing no stress (Somalia, Maputo and South Africa), 11 at Bleaching Watch and 7 at Bleaching Warning level.

Tropical Cyclones

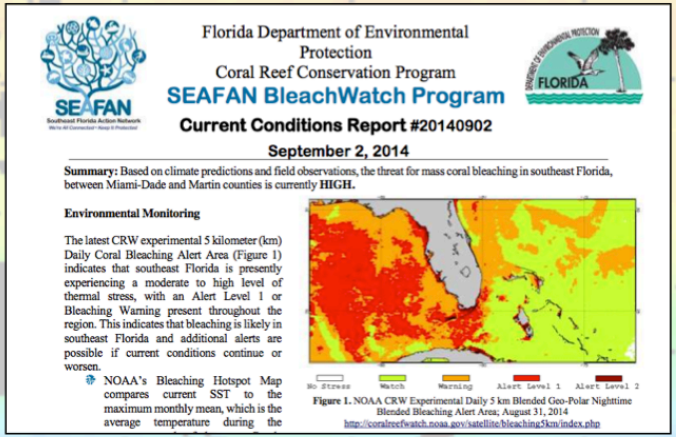
None.

Bleaching observations

Grande Comoros:

Initial observations indicate bleaching is already starting on Grande Comore, at a 'moderate' level. *Said Ahamada/AIDE Comoros*

CORDIO



Florida Department of Environmental Protection
Coral Reef Conservation Program

SEAFAN

SEAFAN BleachWatch Program

Current Conditions Report #20140902

September 2, 2014

Summary: Based on climate predictions and field observations, the threat for mass coral bleaching in southeast Florida, between Miami-Dade and Martin counties is currently **HIGH.**

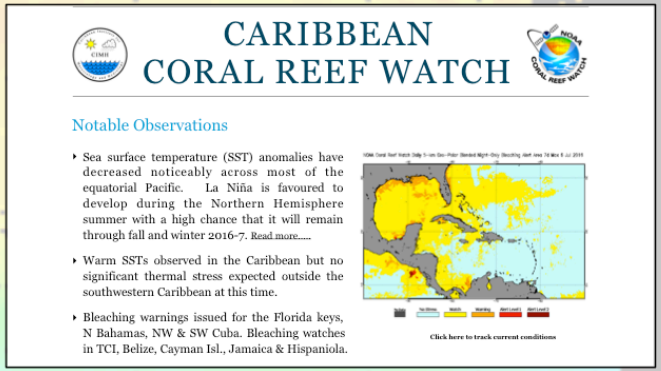
Environmental Monitoring

The latest CRW experimental 5 kilometer (km) Daily Coral Bleaching Alert Area (Figure 1) indicates that southeast Florida is presently experiencing a moderate to high level of thermal stress, with an Alert Level 1 or Bleaching Warning present throughout the region. This indicates that bleaching is likely in southeast Florida and additional alerts are possible if current conditions continue or worsen.

- NOAA's Bleaching Hotspot Map compares current SST to the maximum monthly mean, which is the average temperature during the

No Stress Watch Warning Alert Level 1 Alert Level 2

Figure 1. NOAA CRW Experimental Daily 5 km Blended Geo-Polar Nighttime Blended Bleaching Alert Area; August 31, 2014
http://coralreefwatch.noaa.gov/satellite/bleaching5km/index.php



CARIBBEAN CORAL REEF WATCH

Notable Observations

- Sea surface temperature (SST) anomalies have decreased noticeably across most of the equatorial Pacific. La Niña is favoured to develop during the Northern Hemisphere summer with a high chance that it will remain through fall and winter 2016-7. Read more.....
- Warm SSTs observed in the Caribbean but no significant thermal stress expected outside the southwestern Caribbean at this time.
- Bleaching warnings issued for the Florida keys, N Bahamas, NW & SW Cuba. Bleaching watches in TCI, Belize, Cayman Isl., Jamaica & Hispaniola.

Click here to track current conditions

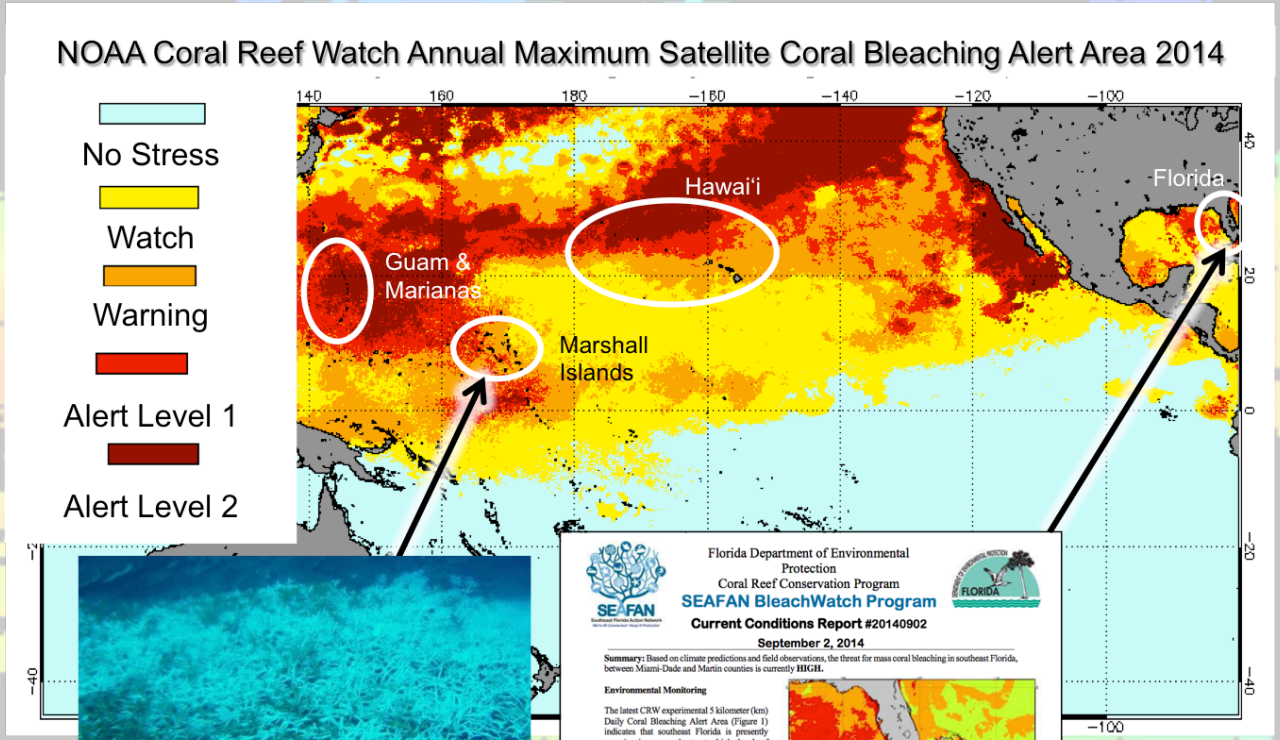
NOAA CORAL REEF CONSERVATION PROGRAM

NOAA CORAL REEF WATCH

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

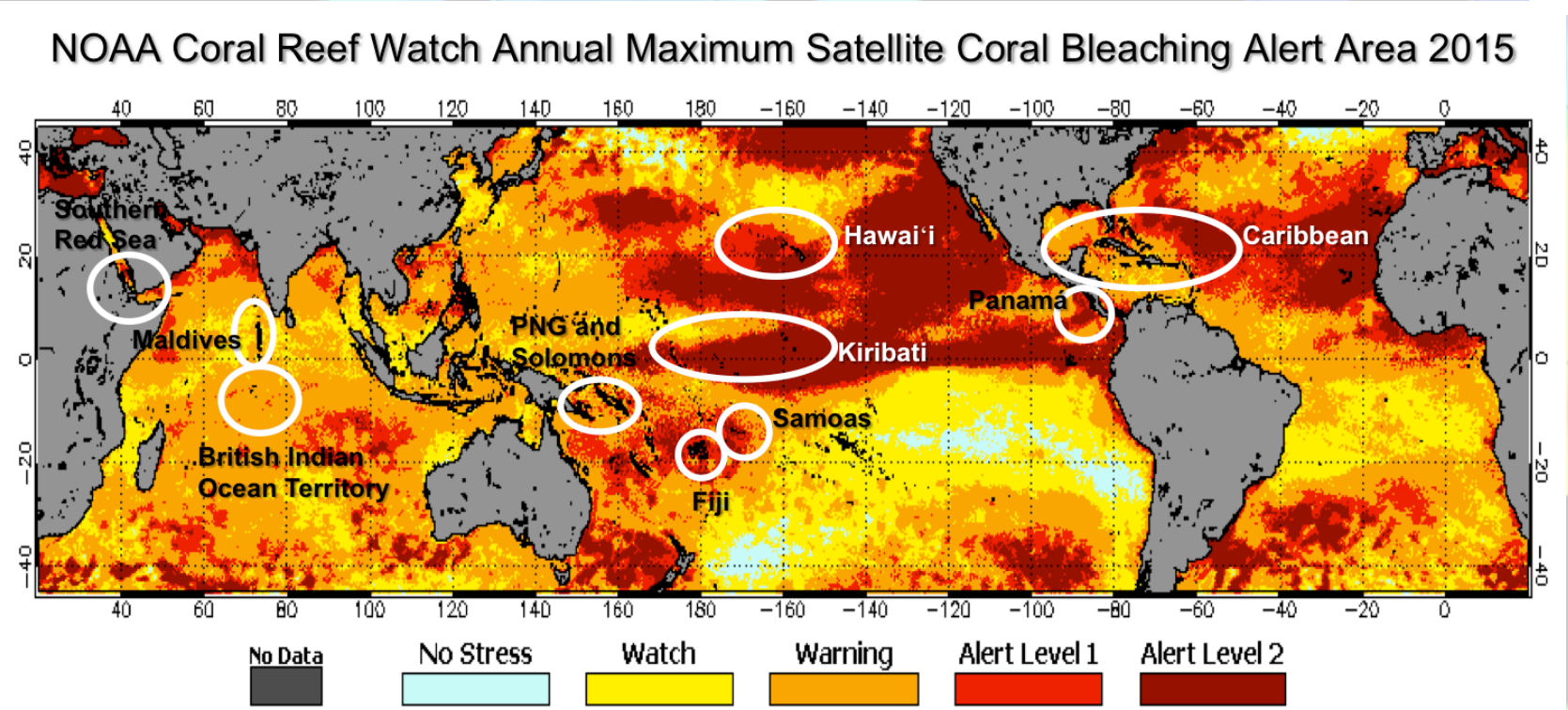
http://coralreefwatch.noaa.gov

Global Bleaching: Last Half of 2014



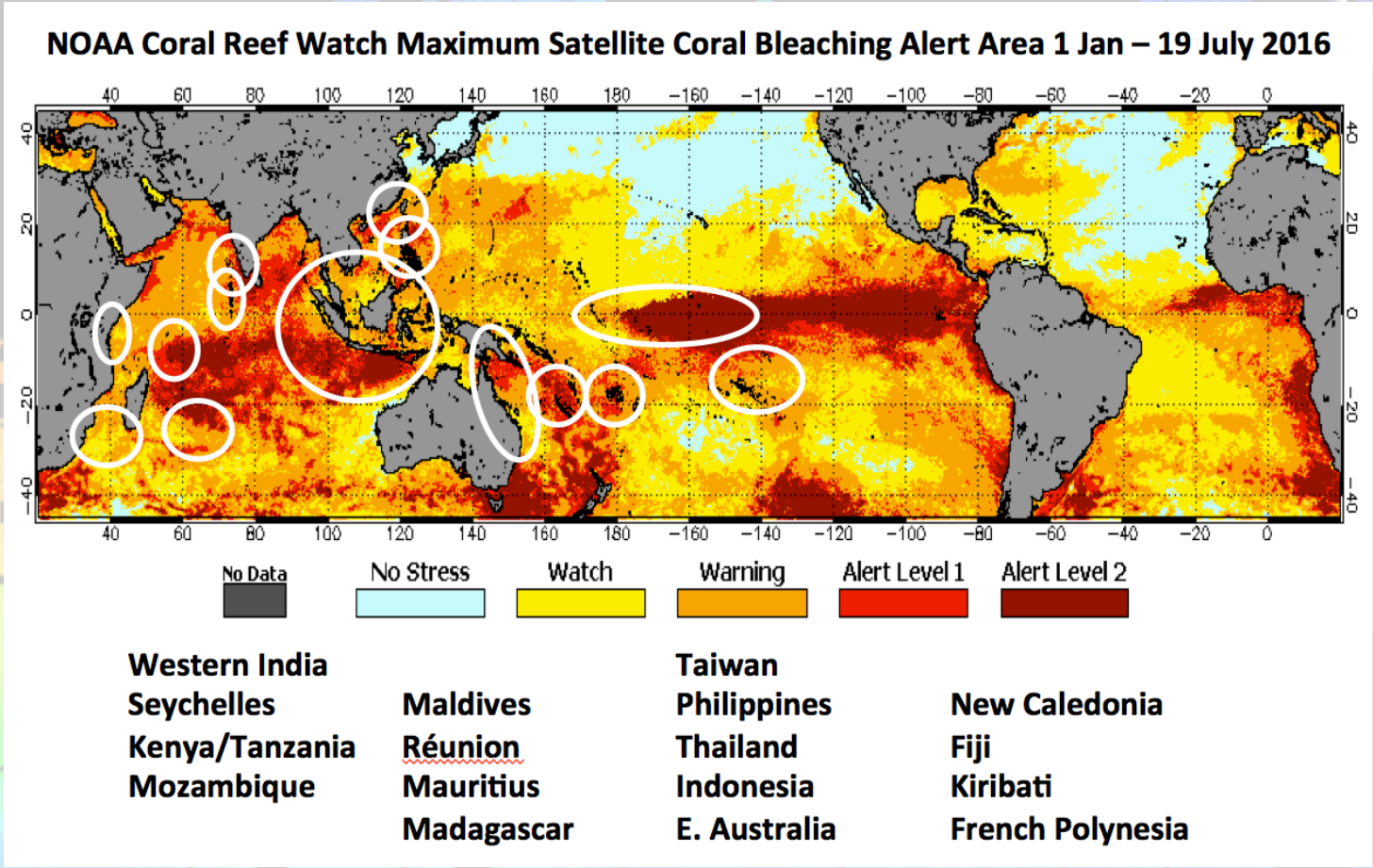
http://coralreefwatch.noaa.gov

Global Bleaching: 2015

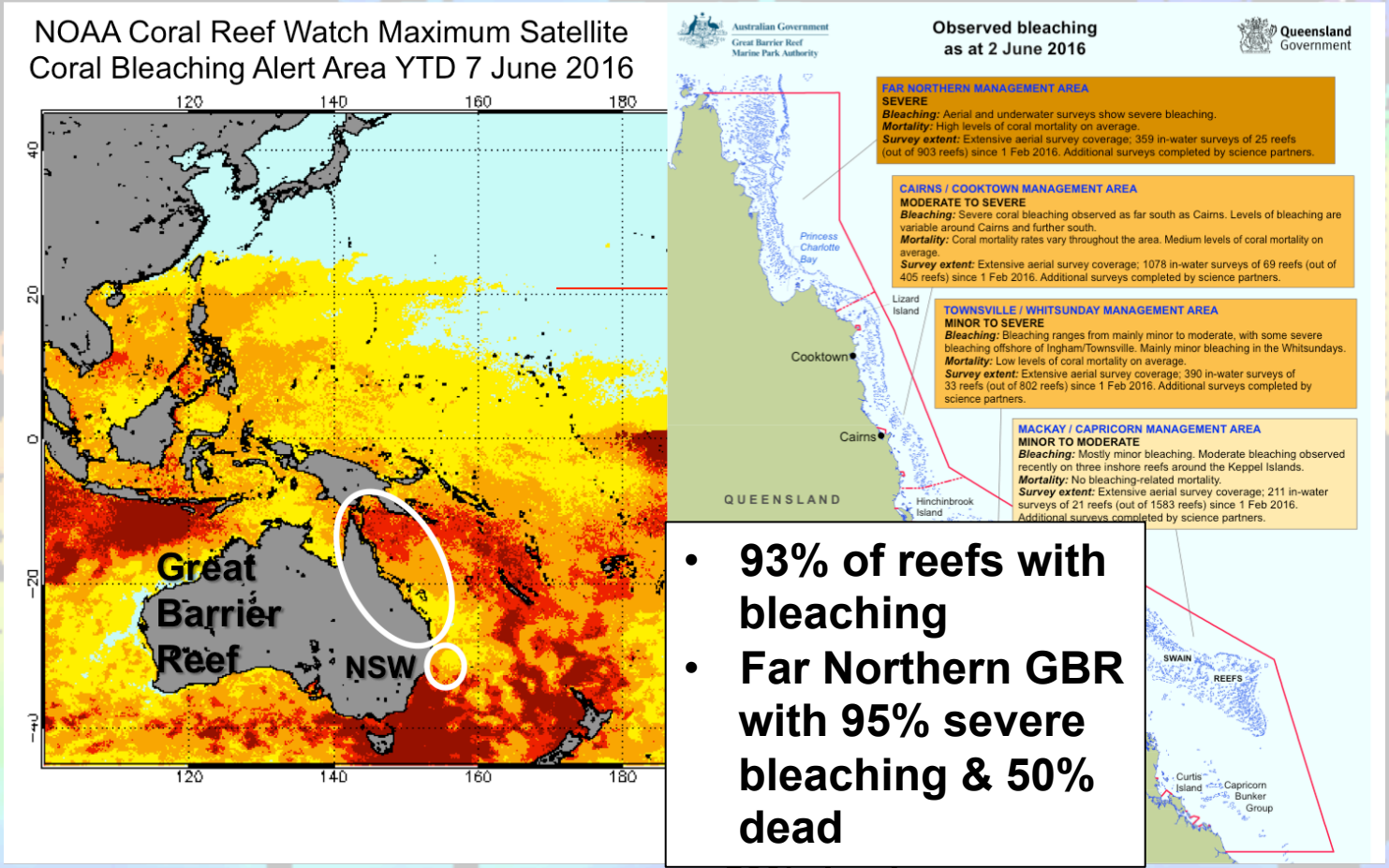


http://coralreefwatch.noaa.gov

Global Bleaching: First Half of 2016



Global Bleaching: First Half of 2016



- 93% of reefs with bleaching
- Far Northern GBR with 95% severe bleaching & 50% dead

Great Barrier Reef Bleaching: 2016

Lizard Island Mortality: 2016

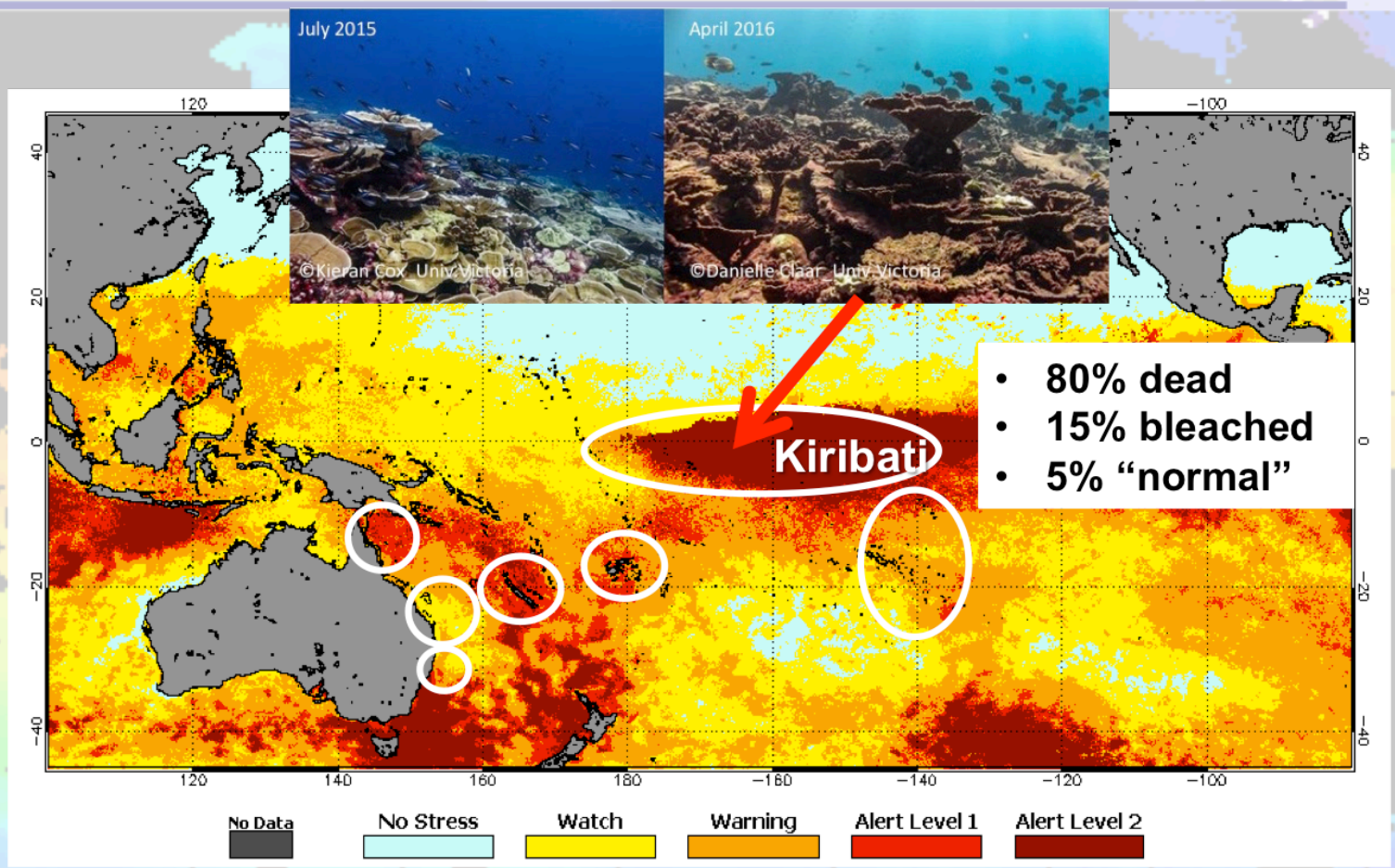
XL CATLIN SEAVIEW™ SURVEY

The lack of fish was an indication that there was “complete ecosystem collapse”
Justin Marshall, Univ. of Queensland
The Guardian 21 July 2016

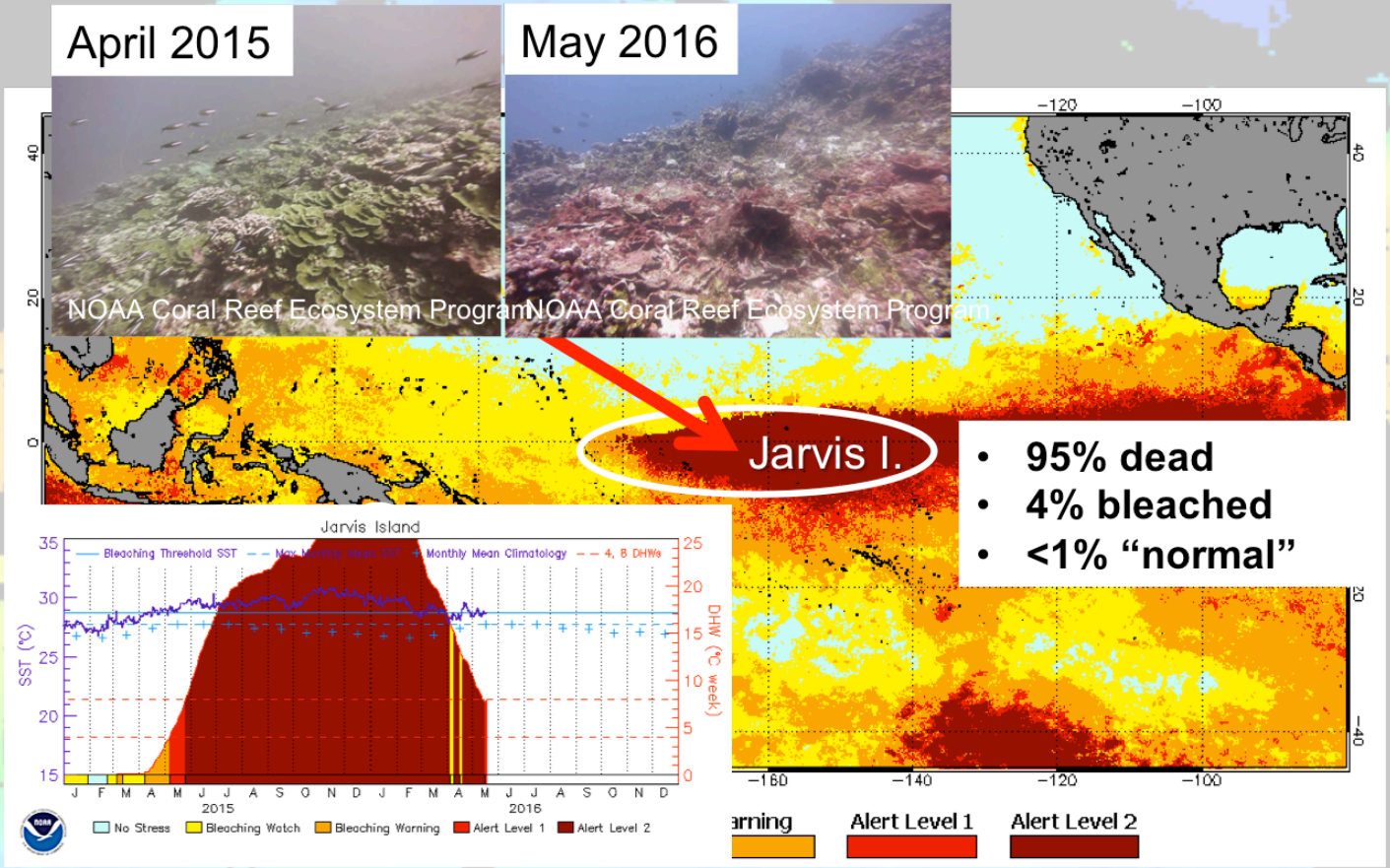
NOAA CORAL REEF CONSERVATION PROGRAM

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

Global Bleaching: Early 2016



Global Bleaching: Early 2016



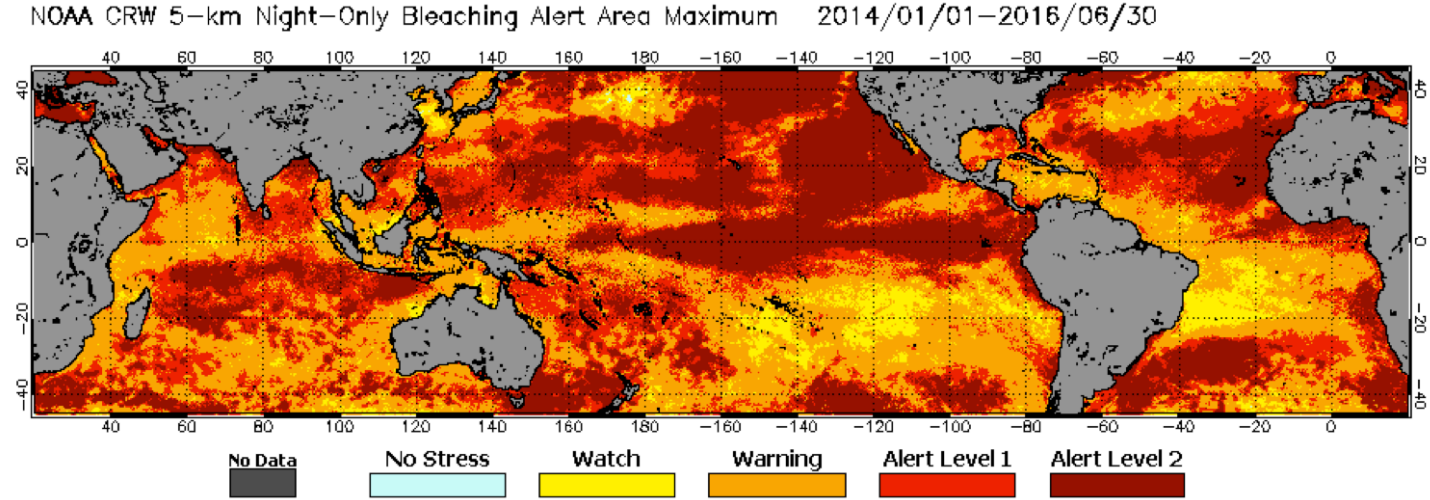
June 2014-June 2016 Thermal Stress

Global Reefs:

- > 40% @ Alert Level 1 or 2
- Level 2 Area > Massachusetts
- Over ½ exposed twice
- ~100% stressed

US Reefs:

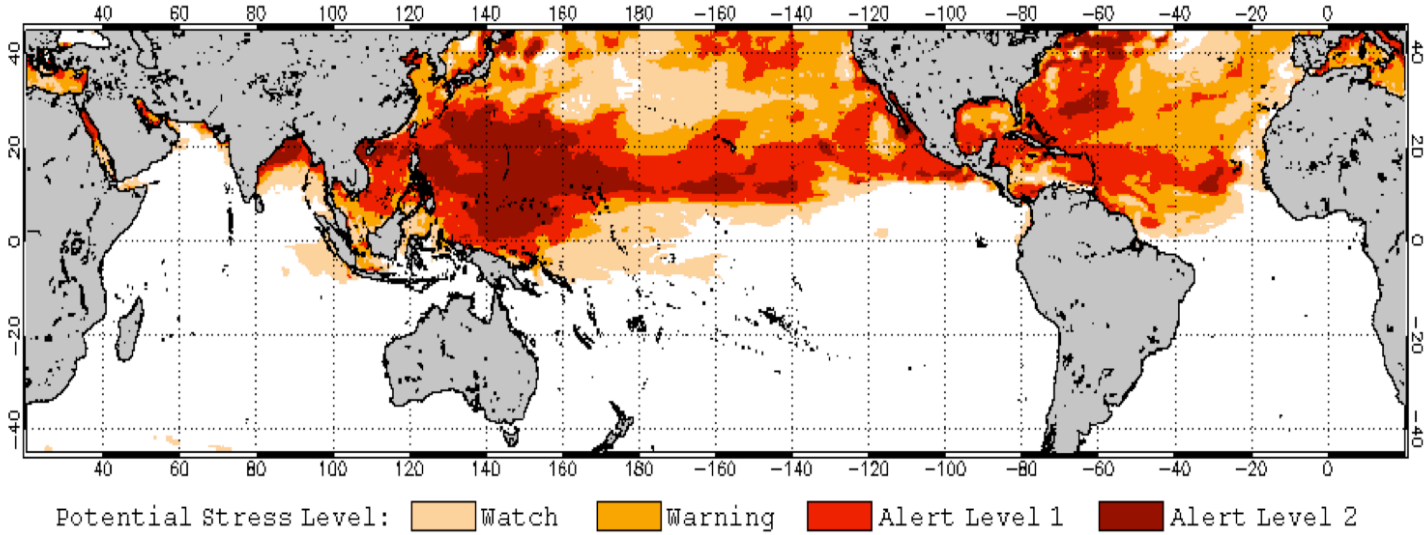
- 72% Alert Level 1 or 2
- Over ½ exposed twice
- 100% stressed



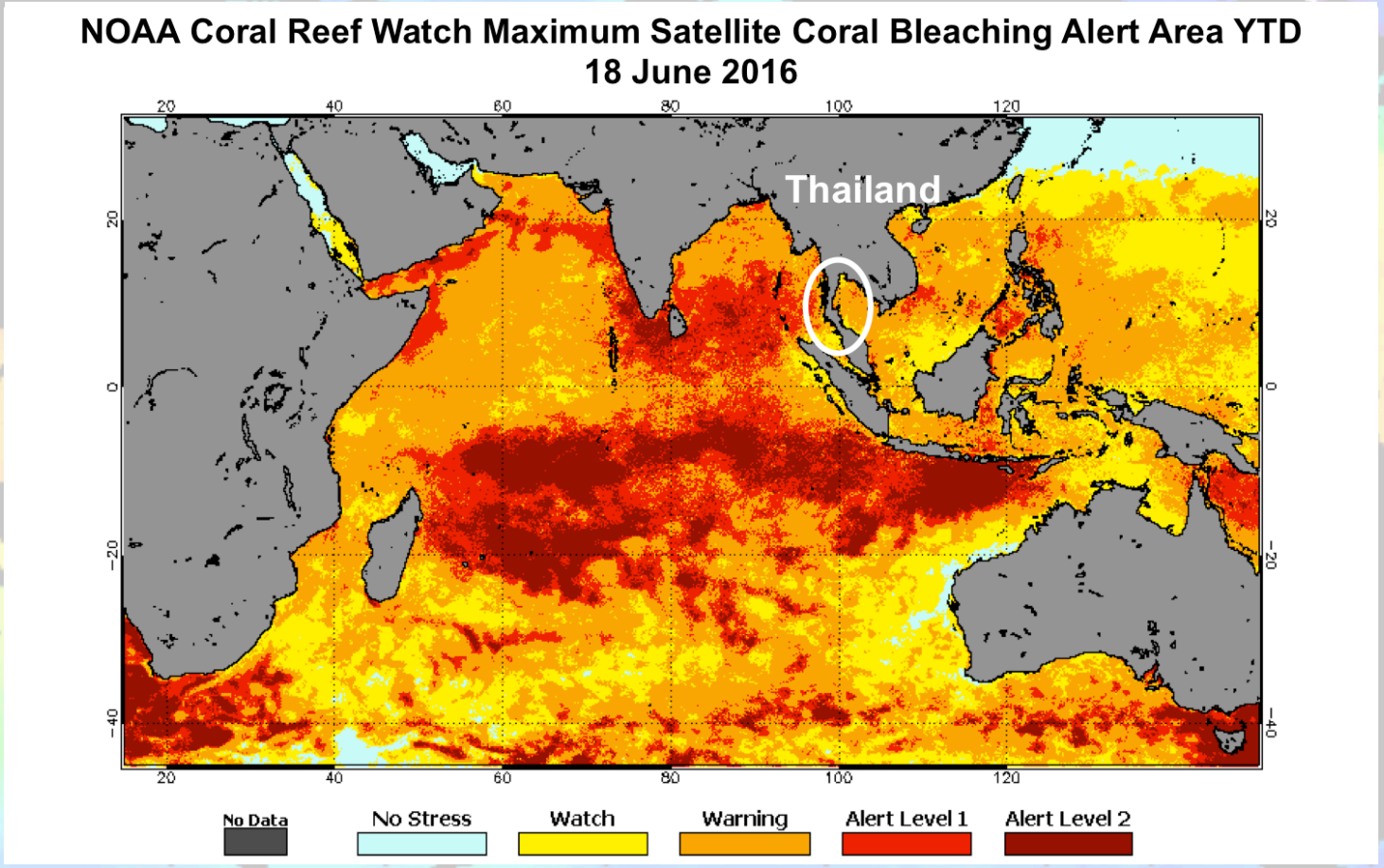
Bleaching Risk Through October 2016

- **Severe bleaching likely in NE Philippines, Micronesia, Guam/CNMI, Marshall Islands**
- **Bleaching likely in Hawai'i, Caribbean**

2016 July 19 NOAA Coral Reef Watch 60% Probability Coral Bleaching Thermal Stress for July - Oct 2016

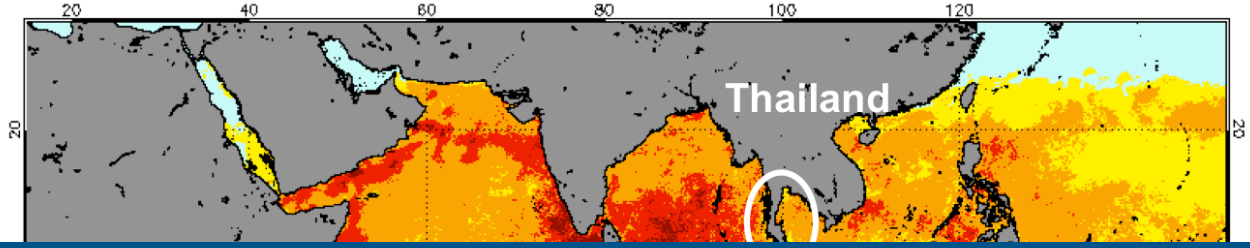


Management Responses: Thailand Reef Closures



Management Responses: Thailand Reef Closures

NOAA Coral Reef Watch Maximum Satellite Coral Bleaching Alert Area YTD
18 June 2016



theguardian
website of the year

home › environment › wildlife | energy | pollution | climate change | UK | world | all

Coral

Thailand closes dive sites over coral bleaching crisis

In a rare move to shun tourism profits for environmental protection, 10 popular dive sites have been shut down in a bid to slow a coral bleaching crisis

Management Responses:
2015 Hawai'i Bleaching – DAR "Ark"

Key Messages

New 5-km product suite

- Just in time for 2014 bleaching
- Higher resolution, better regional products
- Excellent use by community

2014-17? Bleaching:

- Longest, most widespread, often repeated bleaching
- > 40% of global reefs affected
- 72% of U.S. reefs affected

 @CoralReefWatch  CoralReefWatch

CoralReefWatch.NOAA.Gov

NOAA Coral Reef Watch Team
http://coralreefwatch.noaa.gov

Mark Eakin

Jacqueline De La Cour (GST)

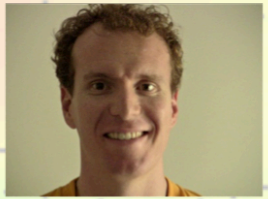
Gang Liu (GST)

Kyle Tirak (GST)

Erick Geiger (GST)

Alan Strong (GST & SRI)

William Skirving (GST & ReefSense)



Scott Heron (GST & ReefSense)

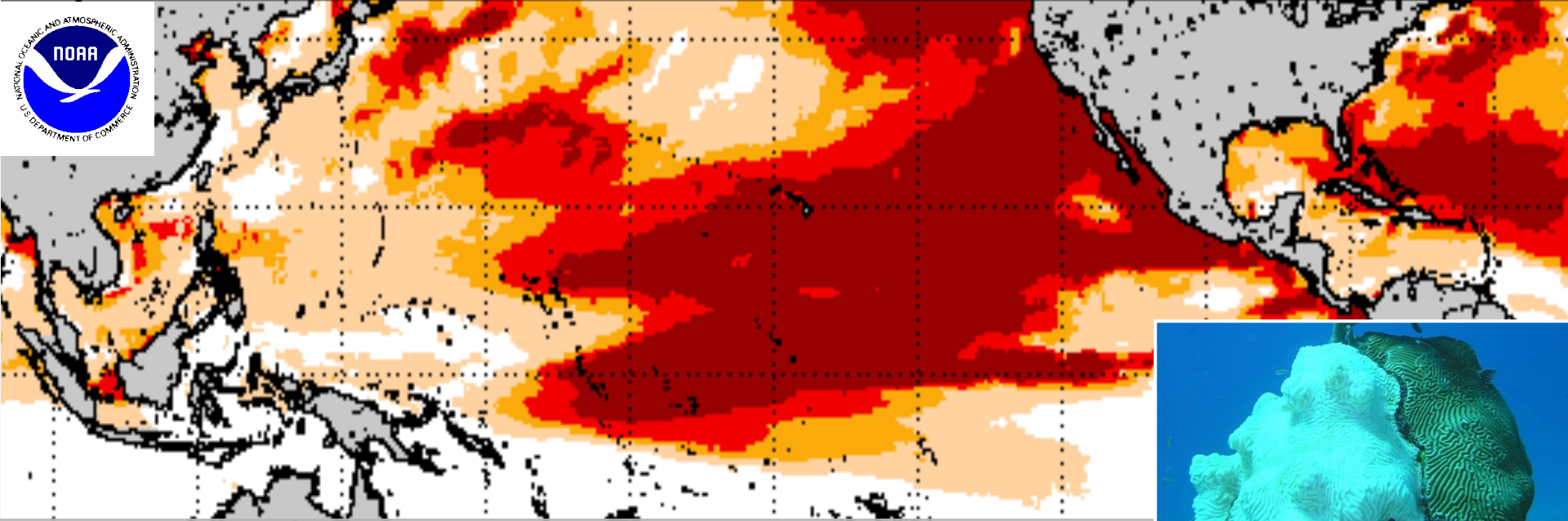
Andrea Gomez (CCNY & NOAA-CREST)

NESDIS
National Environmental Satellite, Data and Information Service

NOAA NESDIS STAR
SMC
CORP
SOC

NOAA CORAL REEF CONSERVATION PROGRAM

GLOBAL SCIENCE & TECHNOLOGY, INC.



Questions?

Dr. C. Mark Eakin
NOAA Coral Reef Watch

http://coralreefwatch.noaa.gov

Coral Reef Watch **@CoralReefWatch**

Week 4 Summary

Week 4 Agenda

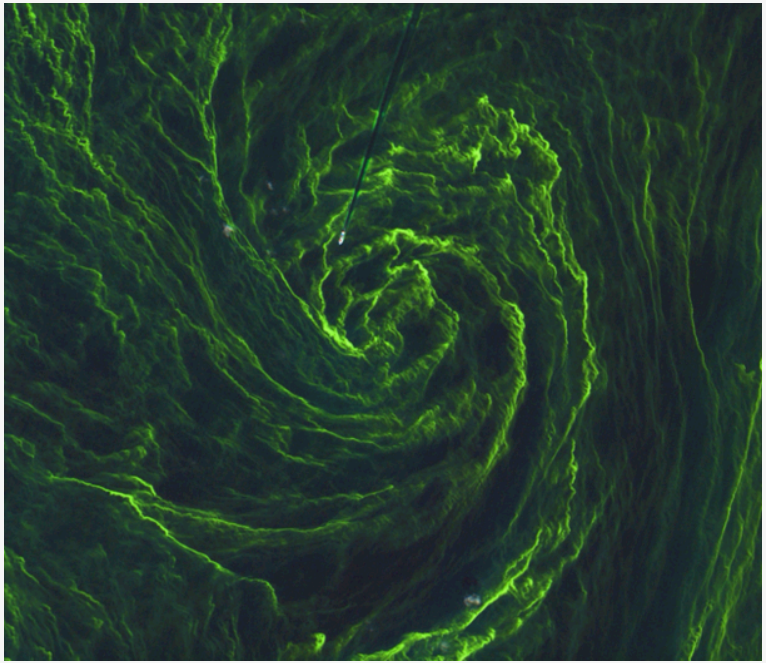
- Overview of coral biology
- Threats to coral reefs
  - Local
  - Global
- Remote sensing of coral reefs
- Examples of remote sensing tools for understanding coral reef systems
- Live Demo:
  - Dr. Mark Eakin: NOAA Coral Reef Watch

Credit: XL Catlin Seaview Survey, Osprey Reef, Great Barrier Reef

Course Summary

- A basic understanding of remote sensing of aquatic systems
- How to access and use NASA Earth science data, tools, and products for ocean and coastal applied science issues
- Demonstrations of Applied Science tools developed in partnership with NASA
  - animal movement
  - coral reefs

Eye of an Algal Storm
Cyanobacteria Bloom in the Baltic Sea



http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-2/Sentinel-2_catches_eye_of_algal_storm

Course Contacts

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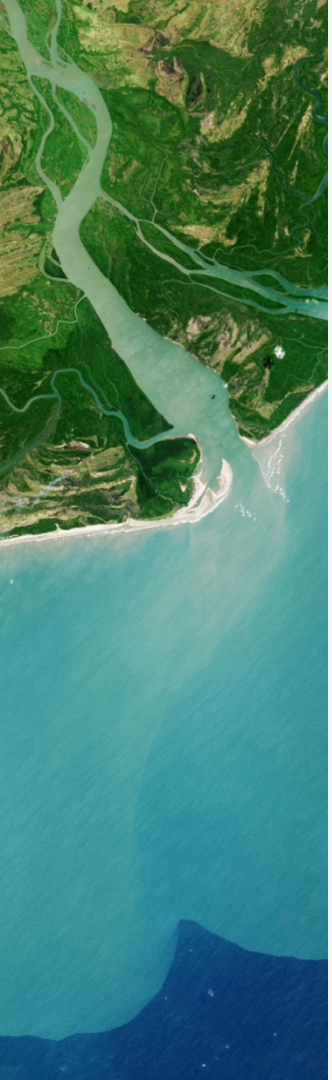
- Cindy Schmidt: cynthia.l.schmidt@nasa.gov

- General ARSET Inquiries
  - Ana Prados: aprados@umbc.edu



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